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THE PRESENT STATUS OF THE TREATMENT OF HIRSCHSPRUNG'S DISEASE*

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SURGICAL attack on megacolon through the sympathetic nervous system gives promise of continuing to produce the spectacular end-results which its introduction in a few properly selected cases heralded. The beneficial effects of lumbar sympathetic ganglionectomy and ramisection, as reported by Adson, Royle, Wade and others, prompted a report, by Learmonth and myself, before the American Surgical Association in 1930, of a modification of the technique of this operation, simpler and without influence on the circulation of the lower limbs.

We have now done either bilateral lumbar ganglionectomy and ramisection, or division of the presacral and inferior mesenteric nerves in eight cases, and we believe one or the other of these maneuvers to be the safest and surest surgical measure for relief of this type of pathologic condition of the colon. Even a cursory review of end-results of both medical and surgical treatment, the latter consisting of resection or drainage, or enteroanastomosis, discloses a high percentage of cases in which treatment has been unsatisfactory, due, no doubt, to the fact that all measures are attempts at restoring physiologic equilibrium to an organ that is without expulsive power, and incapable of emptying itself of huge accumulations of alvine discharges.

There are two types of giantism of the colon which are recognized as separate entities from the standpoint of etiology, and which yet are marked by identical pathologic changes. One of these is the true congenital type (Fig. 1) (the so-called Hirschsprung's or Myà's disease), and the other, the acquired type, which occurs later in life, and is due to a demonstrable obstructive lesion somewhere in the large bowel or rectum.

At The Mayo Clinic, since January 1, 1908, we have had 76 cases of megacolon, 11 of which were of the secondary type, 62 of the idiopathic type, and 3 of the acquired type secondary to carcinoma. Judd and Thompson reviewed 65 of these cases which had been treated by various medical and surgical procedures, and Adson reported 2 treated by lumbar sympathectomy. In 9 of the cases there were associated congenital anomalies, 5 of which were concerned with the anal canal or lower part of the rectum.

ETIOLOGY

The feature of megacolon about which there is most controversy is identification of a factor or factors which would result in this entity. Multiplicity of explanations, or, one would better say, hypotheses, attests the lack of knowledge as to the true cause. It has seemed sensible to us to epitomize the hypotheses under five general

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headings: (1) congenital defects, such as cause Hirschsprung's or Myà's disease; (2) obstructive processes, such as elongation

Fig. 1. Child, three years old, with typical appearance of megacolon.

of the mesentery, torsion of a segment, or multiplication of the intestinal loops; (3) anatomic factors, such as valve conditions, aplasia of the musculature immediately above the rectum, mechanical obstruction, and general systemic conditions; (4) infective processes, and (5) neurogenic processes.

Relief in certain cases of megacolon by lumbar sympathectomy certainly has strengthened the opinion that some of these cases unquestionably are due to derangement of the sympathetic nervous system. Our feeling is that there is a mixed pathogenesis, that the best explanation of the cause of megacolon is that there are often several factors, in the sense that there is an embryonal defect which may be either in the motor mechanism of the bowel itself, or may be explained by ectasia of the intestinal wall, or there may be some mechanical, congenital defect which, although not demonstrably obstructive, produces the three cardinal anatomic features of colonic giantism, namely, dilatation, elongation, and hypertrophy. Attempts to demonstrate mechanical obstruction in the congenital cases have unanimously failed. Efforts to demonstrate faulty nervous mechanism in resected specimens have also been unsuccessful. Segmental spasm, achalasia, and so forth, are equally difficult to prove. The plausibility of the view that anatomic abnormalities, inflammations, or other conditions productive of stenosis, either of congenital or acquired nature, are predisposing factors, is obvious. The opinion that the gross pathologic features demonstrated universally in these cases are results of secondary changes due to some unexplainable and undemonstrable type of obstruction low in the colon, intrinsic, neurogenic, or mechanical, seems difficult to controvert.

PATHOLOGY

The pathology of congenital idiopathic dilatation of the colon (Hirschsprung's or Myà's disease) is the one feature about which there is little, if any, controversy. The description given by Hirschsprung, in 1886, of "a condition of congenital, high-grade dilatation of the colon with thickening of all its tunics, especially the tunica muscularis, and retention of large quantities of fecal matter," is still the most satisfactory word picture of the pathologic characteristics. The two changes, dilatation and hypertrophy, are universally noted in the affected segment, or in the entire colon if it is all affected. In about half of the cases, the condition is localized to one segment. Not infrequently, however, the entire bowel is affected; not a surprising

condition when it is recognized that this pathologic entity may occur in all portions of the gastrointestinal tract. It is unusual to find megacolon in the right half of the colon without its occurring in the left half or in the entire colon, but this occasionally has been noted. The sigmoid is affected in about half of the cases. Next in order of frequency of involvement are the following: the whole colon from the rectosigmoid juncture to the ileocecal coil, the hepatic flexure to the rectum, the cecum to the splenic flexure, the splenic flexure to the rectum, the transverse colon, the hepatic flexure to the sigmoid, and the descending colon.

The dilatation is huge, and in many instances increase in all the diameters of the colon, as well as of its mesenteric attachment, occurs to an almost unbelievable extent. Hawkins reported a case in which the circumference of the affected portion of the bowel was 110 cm., and Graves reported a case in which the whole colon was involved; the circumference was 31 cm., and the length of the affected portion was 110 cm. The circular and longitudinal fibers of the muscular coats are thickened and hypertrophied. There is little peritoneal change. There is, uniformly, elongation of the mesentery, with increase in blood-vascular elements and enlargement of the lymphatic chains. Elongation of the mesentery furnishes the necessary mechanics for volvulus, and this complication is not infrequent. Changes in the mesentery are of sharp definition and its engorgement and infiltration are accurately limited to the involved segment, unless the whole bowel is affected. The thickening at its base, near its juncture with the bowel, as well as its elongation, are characteristic.

Microscopically (Fig. 2), the picture of megacolon is constant; increased thickness of the mucous membrane and increased connective tissue elements, increased vascularity of the submucous coat, thickening of both muscle layers, and but few changes in the serosa.

When one performs exploration for megacolon of a patient who has been properly prepared for operation, usually

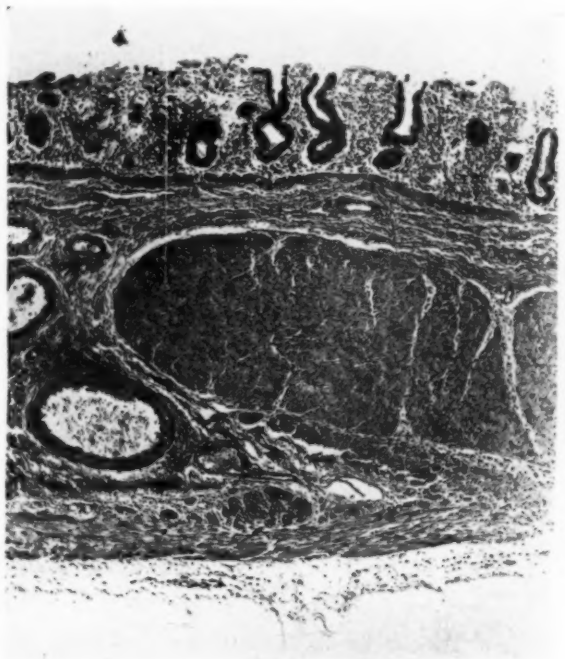

Fig. 2. Section through wall of megacolon. Inner muscular coat markedly hypertrophied; increased vascularity; mucosa considerably attenuated.

the dilatation has been reduced enormously but the hypertrophy continues to be present (Fig. 3). The line of demarcation is sharply defined if the condition of megacolon is segmental, but if it involves the whole of the large bowel, there is difference of degree in hypertrophy and dilatation in different segments. This is a point which has not been properly appreciated but which is readily explained by the mechanics of the condition. The symptoms of megacolon occur soon after birth, and, despite rigorous treatment, or with rigorous treatment to prevent their progress, advance into adolescence or even adult life. We believe the condition is progressive, and results from muscular efforts to pass the content of the bowel through a region of obstruction, either from lack of nerve supply or from some mechanical difficulty such as is produced by elongation of loops which, because of their condition, produce obstruction not recognizable when the

bowel is delivered. Numerous observers have explained the obstruction which occurs, but which is not actually organic, as being due to the weight of the ectatic and ptotic left half of the colon pressing on the underlying sigmoid, which is long and flexed. Such an arrangement obviously would not be found at operation, but theoretically it is a possibility.

The absence of demonstrable obstruction low in the colon has been the feature which has prevented satisfactory exploration. Occasionally, however, pseudomegacolon, if one wishes to call it that, may be produced by definite, organic obstruction; the pathologic changes in the latter condition are identical with those of the true congenital type.

In December, 1928, before the Western Surgical Association, one of us (Rankin) reported 3 cases of megacolon which were due directly to obstructing carcinomas of the lower part of the sigmoid or rectosigmoid. These carcinomas progressed slowly, and occurred in elderly patients who were not disturbed by progressive constipation, and who permitted the obstruction to advance until it was almost complete before seeking relief. Each of these patients had a hugely dilated and hypertrophied colon, filled with fecal matter; indeed, when the abdomen of one

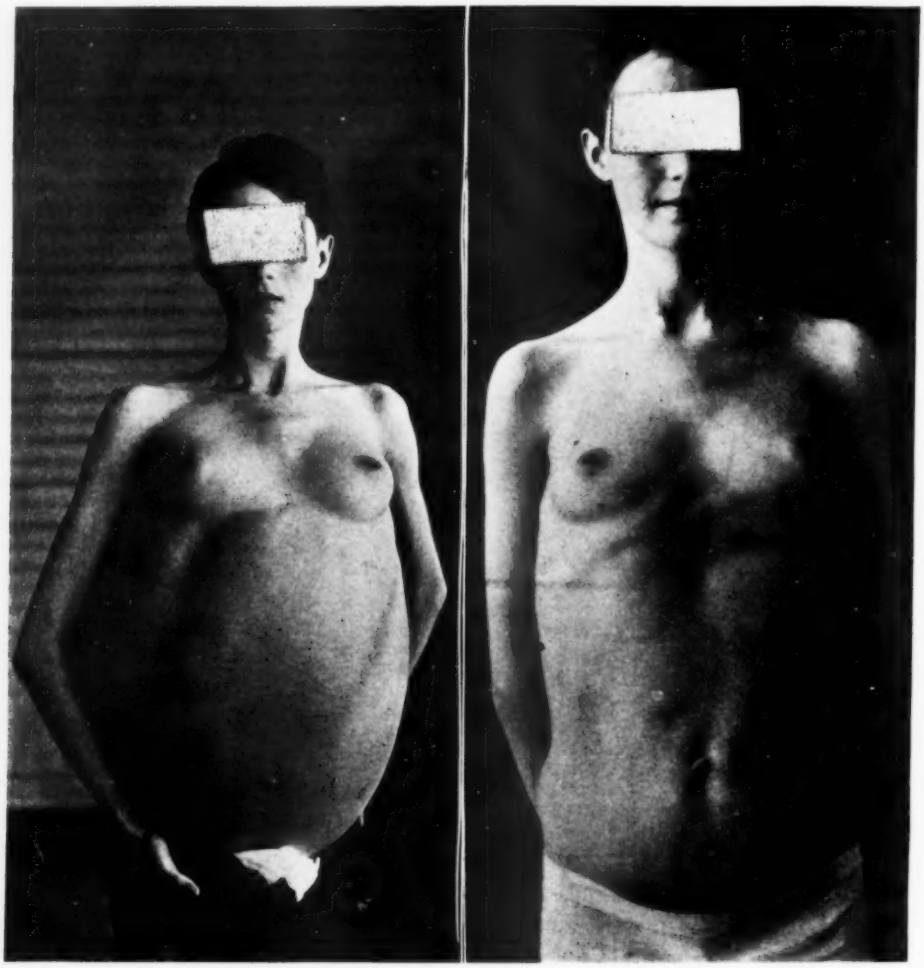

Fig. 3*a*. Fig. 3*b*.

Fig. 3. *a*, Megacolon in sixteen-year-old girl, before treatment; *b*, same patient after medical decompression (refused operation).

of them was explored and the tumor was delivered, it was impossible to return the viscus to its normal habitat and resection was necessary, which, fortunately, resulted successfully. Grossly and microscopically, the changes in these cases paralleled in all respects those of the ordinary type of megacolon which we call Hirschsprung's disease. The mechanics are satisfactory; that is, there is an obstruction against which the bowel works without complete success in emptying itself, and with resulting hypertrophy of the musculature and dilatation of the segment that is immediately proximal to it, or the hypertrophy and dilatation may affect the entire colon. If one accepts the theory that a neurogenic abnormality is the deciding etiologic factor, the same type of productive factor is present, and this will not be demonstrable at operation or in a resected specimen.

OPERATION ON THE SYMPATHETIC NERVOUS SYSTEM FOR MEGACOLON

It is generally accepted that there is a dual innervation of the rectum and of the anus, with parasympathetic and sympathetic fibers. Fibers of the inferior mesenteric plexus end in the musculature of the colon and rectum, and carry impulses which inhibit its activity. Also, it is probable that these nerves exert a continuous influence on the tonus of the bowel. Experimentally it is easily proved, and, apparently clinically in man likewise, as demonstrated in Case II, reported by Rankin and Learmonth, that the thoracicolumbar nerves give the motor supply to this muscle.

So-called sympathetic nerves to this part of the large bowel are derived from two chief sources: (1) the large ganglia in the upper part of the abdomen, celiac, semilunar, and renal, and (2) the paravertebral sympathetic chains. The former nerves descend on the aorta to the origin of the inferior mesenteric artery; the latter are contained in the mesially directed branches of the four lumbar sympathetic ganglia on each side. From the network of nerves around the root of the inferior mesenteric artery, two large strands become separated. These pass out along the trunk of the vessel, and supply the colon with inhibitory nerves from the splenic flexure to the upper part of the rectum. The remainder of the preaortic network descends into the pelvis to join the hypogastric ganglia; inhibitory fibers pass to the rectum, and motor fibers to the smooth sphincter of the anus.

It has been shown by Learmonth and Markowitz that electric stimulation of similar nerves in the dog leads to dilatation of the colon and to contraction of the internal sphincter of the rectum, and contraction of the internal sphincter has been demonstrated by Rankin and Learmonth in the human being when the nerves are stimulated. It has also been shown by Learmonth and Markowitz that after cutting the sympathetic nerves to the colon of the dog, the activity of the bowel is greatly increased.

Various operative approaches have been devised for cutting these nerves. Wade and Royle make use of an extraperitoneal route, in which the lumbar sympathetic chains are reached through a long incision in the flank, after which the mesially directed branches from the lumbar ganglia are divided, and also the main chain itself, below the fourth lumbar ganglion. This operation, which usually has been performed on the left side only, reduces the sympathetic nerves by half, and has proved effective in a large group of cases. Judd and Adson have advocated resection of the second, third and fourth lumbar sympathetic ganglia, on both sides, through a transperitoneal approach. This operation is also curative. It interrupts a larger number of sympathetic fibers, but it has the minor disadvantage of depriving the legs of vasomotor control. In the operation reported by Rankin and Learmonth, the inhibitory nerves to the rectum, and the motor nerves to the internal sphincter of the anus, are first dealt with by resection of the presacral nerve, which is the strand

that conveys to the pelvis the nerves which have been mentioned previously. By following the central end of this nerve upward on the aorta, the inferior mesenteric artery is reached; the inhibitory nerves passing along this vessel to the descending and pelvic portions of the colon are then divided. The operation severs all the sympathetic nerves to the parts of the bowel chiefly affected, and has the advantage of sparing the vasomotor nerves to the lower extremities.

Fig. 4*a*.

Abstracts of Cases from the Mayo Clinic

Case 1. A boy, aged six years, was first seen at The Mayo Clinic June 13, 1931 (Fig. 4*a*). The chief complaints were distended abdomen and constipation. During the child's life he had passed a stool spontaneously only occasionally, and frequent enemas had been essential for any evacuations. The child was distinctly emaciated. All medical measures had failed to afford relief. A diagnosis of Hirschsprung's disease was made, the patient hospitalized, and suitable measures instituted for colonic decompression preparatory to operation. At operation, July 7, 1931, a typical megacolon was found, and bilateral lumbar ganglionectomy and trunk resection were performed. Peristaltic waves were at once observed in the colon, and flatus was expelled a few minutes later. Convalescence was slow but uneventful. Stools were soon passed spontaneously, and progress has been excellent to the present time (Fig. 4*b*). The patient weighs more than ever before and has normal stools with the occasional aid of mineral oil.

Case 11. A youth, aged seventeen years, was first examined in the clinic August 15,

Fig. 4*b*.

Fig. 4. ***a***, Boy, aged six years. Characteristic abdominal distention of congenital megacolon is shown; *b*, same patient, six weeks later, after lumbar ganglionectomy and ramisection.

1929. He had been severely constipated since birth, despite constant use of laxative diets, laxative drugs, and enemas. Roentgenograms gave evidence of an enormously dilated colon, and the diagnosis of Hirschsprung's disease was made. Following adequate medical measures, laparotomy was performed September 3, 1929. A typical megacolon was found and the lumbar colonic presacral nerves were resected. For a few days following, success of the operation appeared doubtful; however, three weeks later the bowels were moving well without the aid of any laxative. When the patient was heard from, about ten months following the operation, he was in excellent health and was passing stools daily.

Case III. A boy, aged two years, was brought to the clinic May 27, 1927, because of obstinate constipation. The child had been constipated since birth and at times had suffered from large, firm fecal impactions, difficult of removal. Occasionally there were short periods of diarrhea. The child was poorly nourished and the abdomen was markedly enlarged. Following the diagnosis of congenital idiopathic enlargement of the colon, the usual medical measures were employed in preparation for operation. June 7, 1927, laparotomy was performed. Marked dilatation of the transverse and descending colon was revealed, and left lumbar sympathectomy and ganglionectomy were performed. Convalescence was without incident and normal bowel movements started within a few days after operation. Normal stools were occurring about one year later, although there was still some abdominal distention. The mother reported that the child had gained in weight and seemed "wonderful" in every way.

Case IV. A boy, aged six years, was brought to the clinic November 7, 1927, because of constipation and enlargement of the abdomen. For one week following birth the child had had no stool and the mother stated that a normal bowel movement had never occurred. Daily administrations of laxatives and enemas were always necessary. A markedly distended abdomen and a greatly dilated rectum and sigmoid were the outstanding features of the examination. After a prolonged medical regimen, bilateral lumbar sympathetic ganglionectomy and ramisectomy were performed December 21, 1927. Dilatation and hypertrophy of the colon started about 20 cm. beyond the hepatic flexure, and extended down to the rectosigmoid juncture. The postoperative course was unusually mild. Enemas were progressively more effective from the third day after operation; a stool occurred spontaneously on the eleventh day, and bowel movements were normal thereafter. When last heard from the boy was in good health, and was passing one or two stools daily with the aid of small amounts of mineral oil.

Case V. A girl, aged eight years, was admitted to the hospital July 14, 1931, with the diagnosis of Hirschsprung's disease. For the previous five years there had been alternate spells of diarrhea and constipation. For periods of three to five months there would be no spontaneous stools, and daily enemas became necessary. The abdomen was distended and the child was underweight. A roentgenogram gave evidence of marked dilatation of the sigmoid, and moderate enlargement of the remainder of the colon. Following proper preliminary measures, the presacral and inferior mesenteric nerves were resected July 21, 1931. A stool was passed spontaneously several hours after operation. Postoperative convalescence was entirely uneventful. Two months later the abdomen was of normal size, the bowels were moving twice daily, and the child's general health had remarkably improved.

Case VI. A youth, aged eighteen years, came to the clinic May 1, 1931, because of abdominal distention and cramps. Since the age of two years the abdomen had become progressively more distended. Abdominal cramps were frequent, and were relieved by passing of flatus. There was no marked difficulty with bowel movements. Laxatives were always ineffective. Roentgenograms gave evidence of huge dilatation of the entire colon, and of a large amount of gas in the bowel (Fig. 5 *a*). The presacral and inferior mesenteric nerves were resected May 12, 1931, and a typical megacolon was observed at this time. Mild infection of the respiratory tract slightly prolonged convalescence. Several weeks after operation stools were being passed spontaneously, and the general condition of the patient now is excellent (Fig. 5 *b*).

Case VII. A boy, aged twelve years, came to the clinic October 30, 1930, with the diagnosis of Hirschsprung's disease. A promi-

nent abdomen was first noticed when the boy was three weeks old. Constipation had existed from the same time, and laxatives were without

the colon confirmed the diagnosis. Following suitable preparation of the colon, operation was performed September 4, 1931, and the

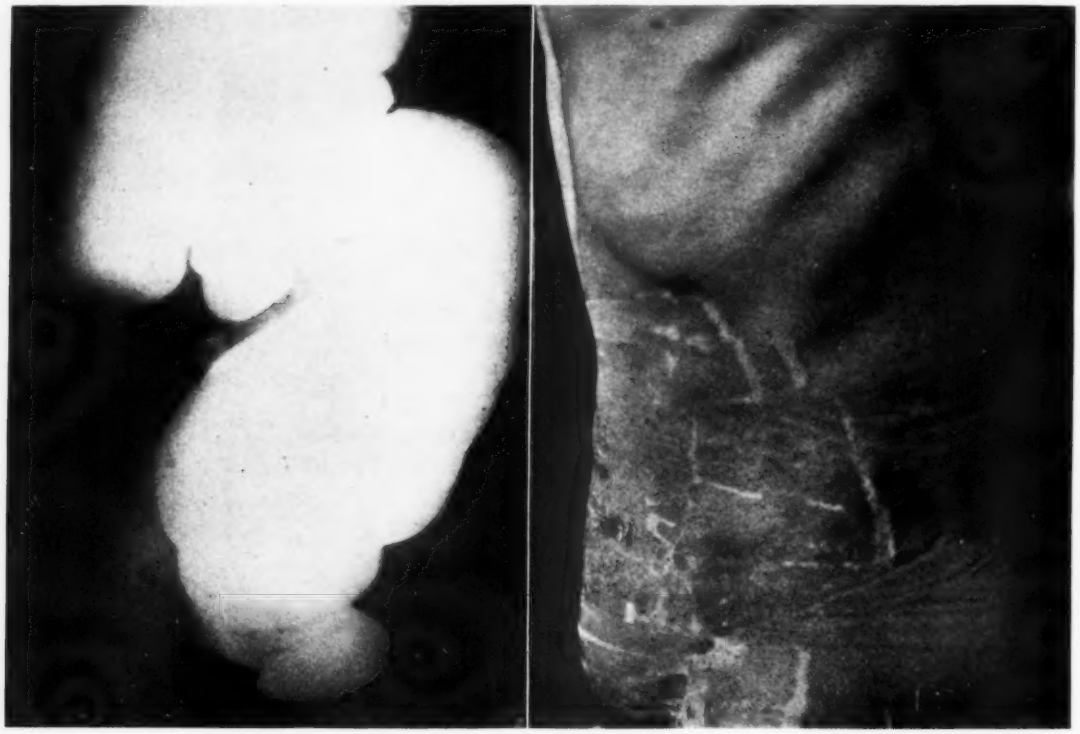

Fig. 5a. Fig. 5b.

Fig. 5. *a*, Hugely dilated colon, characteristic of congenital megacolon; *b*, following division of presacral and inferior mesenteric nerves, absence of abdominal distention which was observed previous to operation is shown.

effect. Enemas caused great distress and their administration had to be discontinued. Examination revealed a poorly developed, undernourished boy, with extreme distention of the abdomen. November 7, 1930, the presacral and inferior mesenteric nerves were resected, and a hugely dilated colon was found, which was progressively larger from the cecum to the sigmoid. Convalescence from the operation was smooth, and a normal stool was passed on the fourth day after operation and daily thereafter. When last heard from, four months following the operation, the boy was gaining weight, was stronger than he had ever been before, and was passing normal stools.

Case viii. A woman, aged twenty-eight years, came to the clinic August 28, 1931, with the diagnosis of Hirschsprung's disease. The patient's father, who is a physician, stated that she had been constipated since infancy and that all laxatives, irrigations, and enemas had become ineffective. Roentgenograms of

hypogastric and inferior mesenteric nerves were resected. Recovery from the operation was uninterrupted. Enemas were at once effective, and flatus was passed spontaneously. The second week following operation a stool was passed spontaneously and gradually these have become regular and adequate.

COMMENT

These epitomes of 8 cases in which offensive measures were directed against the autonomic nervous system lend credence to the hypothesis that at least certain of these cases are indubitably of neurogenic origin. Physiologic basis for sympathetic neurectomy in congenital megacolon lies in the theory that the interruption of these sympathetic nerves deprives the bowel of the "brake" on its activity, and that the tonus of the internal sphincter is, at the same time, diminished, permitting

the bowel, thus, without opposition, to rid itself of its content. Broadly speaking, the sympathetic nerves are thus "filling" nerves, their preponderant action diminishing intestinal contractility and allowing it, in a more or less quiescent state, to accumulate its content. Section of these nerves thus is directed toward the essential pathologic characteristic of the lesion: namely, dilatation and hypertrophy. The former condition permits accumulation of intestinal content and the latter is the result of some type of obstruction. Granted that ideas of the etiology of this condition are somewhat nebulous, the disease may still be attacked by relieving the three outstanding anatomic features, and attempting: (1) to diminish the dilatation of the colon; (2) to overcome the excessive control by motor nerves, and (3) to relieve any opposition to expulsion of the content offered by the internal sphincter. The accomplishment of the first two considerations is brought about by division of the inferior mesenteric nerves, and the third by division of the presacral nerves. This particular type of operation accomplishes these results, as evidenced not only by the 8 cases we are reporting but by numerous other cases noted in the literature and, at the same time, does not endanger the function of any viscera by interruption of important efferent or afferent fibers. The mechanism for defecation is not affected by division of the inferior mesenteric nerves. It will be noted that in the 8 cases recorded here, function was returned, tardily in some, it is true; nevertheless, neurectomy exerted a direct influence, and in all the obstipation and dilatation were overcome in varying degree. The safety of the operation and the desirability of its application in well selected cases, we believe, are established.

WILL BACTERIOPHAGE PROVE THE IDEAL WOUND TREATMENT? *

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SINCE time immemorial, infected wounds have been the surgeon's *bête noir*. One needs only to read Homer and Guy de Chauliac to realize this; and a review of wound treatment through the ages gives amusing evidence of the old adage that doctors differ, and proves again that scientific advance moves in cycles. The search for the ideal wound treatment is centuries old.

Primitive man's wounds were dressed "dry" with moss or fresh leaves, ashes or natural balsams, and when poisoned, treated by sucking and cauterization with red hot irons. The spear and arrow wounds of Homer's heroes were treated with healing ointments, pounded root, astringent, anodyne; but after any of these had been carefully applied, appropriate incantations recited with much religious fervor were considered necessary to insure healing. Religious influence was strong in medicine of the pre-Christian era.

Celsus, famous Roman surgeon in the reign of Tiberius, applied emollient salves to wounds and called on the gods to help. The Greeks invoked the aid of Apollo and Aesculapius.

In 1100 we find more faith in sucking infected wounds than in dressing them with emollients, the most notable example being that of Sybilla, beautiful wife of the Duke of Normandy, who, not caring to live if her husband died, sucked the poison from the dreadful wound in his thigh. She saved his life, but sacrificed her own.

Then came the Middle Ages; and the more repulsive the wound remedy, the more efficacious it was apparently considered. Crushed body lice and incinerated toads top the list of horrors. A powder made from Egyptian mummies and known as "mummy powder" was extremely popular, as were herbs imported from the Orient, and therefore glamorous. Both were dissolved in wine or l'eau de vie.

In Mme. de Sevigné's day, psychic influence enjoyed a brief popularity. The soldier's wound was quickly washed and bandaged, and then the weapon which had inflicted the wound carefully dipped in wound ointment. The patient improved.

Digby did not treat the weapon, but ingeniously applied "sympathetic powder" to the soldier's discarded clothing at the point where the wound had soaked it in blood.

In Paré's time, it was a common thing for maggots to breed in a wound if the latter was left undressed for a single day; and the favorite precaution against wound infection was to pour into the wound tract boiling oil or molten pitch, in which elderberry bark had been dissolved.

Paré also seems to have given unusual importance to diet and the patient's comfort in the healing of infected wounds. Take the case of the Marquis d'Arnet, whom Paré treated for an infected wound of the thigh from an arquebus shot. The physicians who had been treating him for weeks before Paré was called had not changed the patient's linen in all that time for fear of disturbing the wound. Paré immediately ordered fresh clothing and bedding, made three openings in the thigh, took out bone splinters, cleaned the wound with boiling oil, put in drains, and applied plaster with a window.

But his treatment did not stop there. He ordered that the patient be fed a succulent diet of broth and herbs, wings of partridge, plums stewed in wine, sorrel, chicory, marigolds, and a list of delect-

* Submitted for publication, October 28, 1931.

ables that would almost make one envy the Marquis his wound. Not only this; but for hours the patient was to smell flowers of herbane and water lilies bruised with vinegar and rose water with a little camphor. Artifical rain was to be produced to make him sleep. Viols and violin soothed him and a comedian was summoned by the doctor to make his patient merry. Is it any wonder that his convalescence was short?

A poet has paraphrased the after-treatment of wounds in those days:

> Use three physicians still. First Dr. Quiet
> Next Dr. Merryman, and Dr. Dyet.

By mere accident, Paré learned to doubt the efficacy of boiling oil as an anti-infectious agent. After a battle in which many soldiers were wounded, the boiling oil in the great kettles behind the lines gave out. Paré desperate for the welfare of his wounded, used a cold mixture of yolk of egg, oil of roses, and turpentine. Then he spent a sleepless night, worrying lest they die for want of boiling oil. To his surprise he found in the morning that these soldiers were in better condition than those whose wounds had been treated by the routine method. Thereafter he used the cold dressing.

The variety of ingredients used for poulticing infected wounds in different countries and different eras is amazing: herbs, ashes, blossoms and roots, bread and milk, linseed meal and boiling water, marshmallow water alone, or cold water mixed with saltpeter, vinegar and sal ammoniac.

Heister, a German army surgeon of the 1700's made a distinction between "ardent and phlegmatic temperaments," using poultices of vinegar for the former, and for the latter brandy or spirits of camphor —always some heating agency. In Heister's time, salves, plasters, vitriol, nitrate of silver, "lint," all had their advocates.

Gooch used a wax sheath to cover his wounds, and left them alone. If his technique were described in more detail we might find a resemblance to bipp or the Orr treatment. At least he practiced the doctrine of non-interference.

The early German school, instead of salve-smearing, probed infected wounds unmercifully and filled them with quantities of lint. Würtz of Basel, in 1576, protesting against this method, said, "Medicines belong in wounds, and not such rags. The pus is thereby obstructed and cannot come out through the bolted door as it needs to do, and as Nature eagerly forces it." Nevertheless the probe-and-lint practice persisted for nearly two hundred years. Richter later adhered to the principle that Nature accomplished the healing, and all the surgeon should do was to remove grave obstacles.

Bell insisted on the free and unobstructed flow of pus, and to that end introduced lead tubes. In 1760, lead preparations for wound treatment were introduced in France by Goulard of Montpelier.

To the end of the 18th century the dogma of the injurious effect of atmospheric air on wounds prevailed. Hence the popularity of Paré's mixture of egg yolk, oil of roses, and turpentine: it hermetically sealed the wound. To keep out air, bandaging was done with lightning speed as soon as the salve-smearing process was complete, and the bandages changed "as seldom as cleanliness would permit." This does not mean 20th century cleanliness.

Hunter, in connection with his classic study of circulation and inflammation, remarked that it was sometimes "just as well to let a wound alone."

The 19th century was one of antiseptics and caustic germicides introduced by Lister. We are accustomed to think of this as a new departure; but more than two hundred years before Lister (1628) Woodall,[6] an army surgeon, sharply attacked the "innordinate and meddlesome use of strong caustics." In his day, these were zinc and copper sulphates, mercurial salts, and sugar of lead.

Various balsams (of Peru, of Mecca, of white amber) also enjoyed popularity in the nineteenth century.

With the World War came the Carrel-Dakin treatment, the acme of antisepsis. It combined qualities which no previous antiseptic had: it did not harm the tissues, it dissolved the wound exudates, and permitted the nascent chlorine which it contained to penetrate to the bacteria in the recesses of the wound. I was one of its most enthusiastic advocates, having studied the details of the technique in Carrel's hospital at Compiègne, France. Subsequently, while Chief Surgeon at U. S. Gen. Army Hospital No. 3 during 1918 and 1919, I made a comparative study of this and other accepted wound treatments. The results of the Carrel-Dakin method proved so far superior that, early in the fall of 1918, I adopted it as the exclusive wound treatment. Of the 6000 serious bone cases which came under my care at this Army hospital, I can safely say that half owe useful extremities to conquest of wound infection by this method before reconstruction surgery was attempted.

But in spite of these excellent results, there were obvious objections to the treatment, and as the rush of war surgery abated, these objections gained more weight: The frequency of irrigation and dressings were distressing for the patient, arduous for the surgeon, and associated with risk of re-infection. It also necessitated prolonged hospitalization, a serious drawback to any treatment. The softening of the cast by the fluid and the necessity of cutting a window for insertion of the tubes rendered immobilization, so important in bone cases, imperfect; and also induced edema in the wound granulations and surrounding soft tissues within the area of the window, an unfavorable condition for wound healing. A uniform pressure over the wound as well as neighboring structures, such as is furnished by the Orr dressing, is most desirable. Under the Carrel-Dakin method, disinfection was in a sense working at cross purposes with immobilization and with the ultimate goal, bone repair.

In 1923, Orr[7] proposed a method for treating osteomyelitis which was the absolute antithesis of the Carrel-Dakin. For antiseptics, he substituted a vaseline dressing without germicidal power; instead of perpetual interference, he put on a cast and let the wound alone for weeks. For some time I hesitated to try this treatment; for, excellent as Orr's results were, the method seemed absolutely empirical and contrary to all previous conceptions of wound dressing and drainage. Finally, however, the annoying features of the Carrel-Dakin treatment of bone wounds, particularly its interference with immobilization, induced me to give the new method a trial.

I shall never forget with what trepidation I "unearthed" that first case of Orr treatment. The dressings under the cast were soaked with fetid pus. But as soon as the packing was removed and the wound wiped off, I was reassured by beautiful glistening red granulation tissue, as healthy as in the most satisfactory Carrel-Dakin treatment.

However much the vaseline and vaseline gauze method might seem to violate the traditions of free drainage, it was obvious that the process was sound. Soon after operation the patient's temperature had dropped to nearly normal and remained so during the eight weeks that the dressing was undisturbed. This fact and the healthy appearance of the granulations showed that instead of toxins being absorbed, they had been thrown off into the pus soaked dressings.

Orr's explanation (rest, immobilization, non-interference, and avoidance of re-infection), did not seem to me to account fully for the marked and unexpected success of the treatment, and observation of several cases convinced me that some unusual phenomenon was befriending both patient and surgeon.

In 1921, d'Herelle,[8] a French bacteriologist at Yale University, claimed to

have found an ultramicroscopical parasite of pathogenic bacteria which had markedly beneficial effects in certain acute intestinal diseases, such as bacillary dysentery and cholera. This parasite he called the "bacteriophage" because it lived on virulent pathogenic bacteria and destroyed them, thus in many instances saving the patient's life. There were, he demonstrated by laboratory experiment, several varieties or "races" of phage, each with a preference as to the type of bacteria it would destroy; but also having certain adaptable destructive influences toward other strains of bacteria.

In the mass of detailed bacteriological findings which d'Herelle presented, two experiments struck me as having a definite similarity to what had happened in the Orr-treated wound, and to offer a possible explanation.

In one of his earliest experiments with dysentery bacilli he added about 0.0001 c.c. of bacterial culture to a young broth culture and subcultured the mixture immediately to an agar slant. Ultimately the surface of the agar was well covered with a roughened layer of the multiplying bacteria. Then, after a long period of time, two little islands appeared, two clear plaques perfectly circular in form where the agar was bare, entirely free of all traces of the bacterial colony. D'Herelle explained this striking phenomenon by the spontaneous appearance of a bacteriophage which absolutely destroyed the bacteria with which it came in contact.

To prove this, his next step was to apply a platinum loop to the roughened surface of the agar and transfer a bit of the bacterial colony to a test tube of clear bouillon and incubate it. Within a short time, the tube was so teeming with bacteria that it was turbid and opaque. D'Herelle then transferred to this turbid culture an infinitesimal portion of one of the clear plaques on the agar slant. After a few hours, the bouillon, as if by magic, became perfectly clear and transparent, and centrifuging of the culture failed to disclose any bacteria whatsoever. Not only had all bacteria been killed, but their bodies had been lysed or dissolved.

Now if a chemical germicide had been placed in this tube or heat applied, the bacteria would have been killed, but at the bottom of the tube there would have been a sediment, a deposit as a result of centrifuging, millions of dead bacterial bodies. Not so in this tube of D'Herelle's. There was not a trace of sediment. Not a dead bacterial body could be found.

The analogy to the Orr treated wound is obvious. When one closes up the wound with vaseline, vaseline gauze, and plaster cast, it is teeming with infection. When one removes the dressing eight weeks later, the wound is clean and healthy. Whatever agent cleared out the offending infection appeared spontaneously as on d'Herelle's slant culture, for none had been introduced. And the long lapse of time, just as in his experiment, permitted this natural agent to carry on its bacteria-destroying action to a successful end. Was it not logical to assume that the phage principle had been working in the wound?

According to d'Herelle's deduction, certain races of phage were always present in the intestinal tract of man, but in varying amounts. Their parasitic activity apparently increased with the number and virulence of the bacteria with which they came in contact over a period of time.

D'Herelle also found that it was possible to increase and intensify this parasitic action by administering doses of phage culture, the additional phage being obtained from sewage. Isolation of phage in this manner is possible because the phage is so infinitesimal that it will pass through the finest filter after everything else has been screened out. The residual phage filtrate will of course contain many races in varying quantities. In order to isolate a given race in potent form, the bacteriologist introduces into said filtrate a culture of the bacterial strain on which that particular race thrives. The desired phage thus has an opportunity to gorge itself

with bacteria and multiply at the expense of the other races which have but a starvation diet. Before long, a pure strain of the desired phage persists.

D'Herelle's writings dealt chiefly with his laboratory work and with the treatment of intestinal diseases. Nothing had been said about bacteriophage in connection with osteomyelitis or the treatment of infected wounds.

But while I was searching for the cause of the unusual success of the Orr treatment, it seemed to me that practically the same conditions were brought about by the long and undisturbed dressing of the wound as occurred naturally in the old and attenuated bacterial culture in d'Herelle's test-tube. Was it not quite possible that a native bacteriophage had multiplied and become active under the long-continued dressing?

Pursuing this idea further, it occurred to me that the closest analogy existed between this phenomenon and the one which I had often observed in the citrus groves of my Florida estate. One of the orchard grower's problems is how to destroy the purple scale, which kills orange trees just as bacteria kill human tissues. There are open to him two methods of combat. He may spray his trees with a strong chemical which parallels the Carrel-Dakin treatment; or he may let a parasite fight the battle instead.

This is the red-headed ray fungus, a parasite which exists in orange groves by eating the purple scale. The threads of the fungus penetrate the body of the scale and eventually kill it as well as the eggs it contains. If the fungus does not of itself arrive in the grove, the gardener may import it. For certain other pests, he may introduce lady beetles if they do not spontaneously appear, as they often do. Fruit growers now seldom spray trees with chemicals to destroy certain pests if they can make use of a living parasite or natural enemy, for the latter method is much more reliable. In fact, some pests are more resistant to chemical sprays and can only be eradicated by a natural enemy or parasite.

By careful laboratory search and tests, the race of phage which the surgeon needs for a particular case can usually be supplied if it does not appear spontaneously. In bone cases the specific phage for the para colon and staphylococcus are most potent. These we have checked in careful laboratory studies of cultures from infected wounds. Every bacterial smear that comes into the laboratory is tested to determine what phage will be effective.* In those cases where the phage does not spontaneously appear to work its beneficial parasitism in the wound, the laboratory-bred phage of the desired race is introduced.

In about 94 per cent of cases of acute and chronic osteomyelitis, a specific phage occurs spontaneously. In 3 of the remaining 6 per cent in which the phage does not appear spontaneously, the laboratory is able to supply us with a phage specific for the organism in question. But in the other 3 per cent, it has so far been unable to do so. This is particularly true of the Streptococcus hemolyticus, and in the cases where the bacterial smear from the wound yields this streptococcus, we have been forced to adopt the principle of watchful waiting. To our surprise, in several instances, the desired phage has later appeared in the wound spontaneously and healing has occurred. It is hoped that with the perfection of laboratory methods and increased knowledge of the phage, it may be possible to isolate races of phage specific for each bacterium. In that case, we would have the ideal wound treatment, an active living agent, capable of self-reproduction.

In order to accentuate and reinforce the effect of the spontaneously appearing phage, I am now introducing, in selected cases, a specific laboratory-bred phage. A report of the results of this combined method will be published later.

* Thus far our laboratory has been able to isolate twenty-five races of coli phage, four of staphylococcus phage and one of streptococcus phage. These we have used successfully in clinical cases.

The operative technique which should be applied to osteomyelitis, both acute and chronic, will be discussed here.

OPERATIVE TECHNIQUE FOR ACUTE OSTEOMYELITIS

In acute infectious osteomyelitis, the surgeon is confronted with active infection, necrosis, suppuration, and more or less general intoxication. The keynote of treatment is the immediate evacuation of pus, as indicated in any other pyogenic process.

For rapid and effective entrance to the marrow canal, the author has found his motor-driven instruments far superior in every respect to any hand tools yet devised. Multiple openings can be made into the marrow in a fraction of a minute by means of the large motor-drill. If pus is revealed by this procedure, the initial opening may be rapidly enlarged by the motor twin saw, which can be made to cut a trough in the bone of any desired dimensions. The ends of the trough can be cut with the cross-cut saw, and the portion of the cortex between the cuts pried off with a chisel. If motor-driven instruments are not available, the surgeon can use trephine, gouge, chisel, and mallet for this purpose. The opening into the marrow canal should be progressively enlarged until no more pus is evacuated; if necessary, the cortical lid should be removed from the entire length of the shaft, producing a gutter the length and width of the medullary canal.

The surgeon should avoid curetting the marrow, in order to preserve as much of the endosteum as possible for reparative osteogenesis and to prevent necrosis of the inner layer of cortical bone which is likely to follow its removal.

If the epiphysis is involved, a portion of its cortex must be removed for drainage, but the epiphyseal line should be avoided if it is possible to do so. If the joint also is involved, it should be incised, irrigated, and drained. The bacteria-resisting properties of the epiphyseal cartilage almost always prevent invasion of the epiphysis. The entire wound produced by the operation should be thoroughly packed, from the skin margins to the bottom of the medullary canal, with yellow vaseline and vaseline gauze, and this efficient drainage of the bone should be maintained for three or four months, or until thorough sequestration has occurred and the periosteum has produced a sufficiently thick involucrum (as indicated by *x*-ray examination), at which time the sequestrum should be entirely removed. The packing and dressing should not be renewed until six to ten weeks later in order to secure the best effects from the spontaneous appearance of a specific bacteriophage or one that may be introduced by aid of the laboratory.

OPERATIVE TECHNIQUE FOR CHRONIC OSTEOMYELITIS

The extent of the bone lesion having first been determined from the *x*-ray, a suitable incision is made for its eventual complete exposure. Generally speaking, it is desirable to approach the bone where it is most superficial; but important anatomical structures may frequently debar this, as well as the danger of damage to peripheral gliding joint structures, or of induction of adhesions between them, or between important muscles and underlying bone. If a sinus persists, it is better, when possible, to include such infected tissue in the incision so that scar tissue and necrotic tissue may be trimmed away. When an incision is meant to include a sinus, a forceps or blunt-ended instrument, never a probe, is first inserted into the sinus to determine its direction and to serve as a guide for the incision. The incision should not follow the sinus unless, anatomically speaking, it is indicated. The incision is always made in the long axis of the limb, and is never carried through a muscle group, such as the quadriceps. It is preferable to follow the general line of cleavage between muscle groups. If there are any sequestra they are removed. For removing the cover of the sequestrum pocket, one

may use the single motorsaw, but as a rule, the osteotome is more practicable. Sufficient bone is removed to uncover the entire pocket, as only complete exposure will reveal its extent. The primary bone incision is carried beyond the line of demarcation of affected bone, if it has not separated. Overhanging ledges are removed until the sequestrum pocket takes on a contour simulating a saucer, or a perforating hole must be transformed into a valley with sloping walls by removing all bone from one side. This is important because as healing occurs, the contraction of cicatrization draws the soft tissues into close contact with the bone in precisely the same manner as a purse string, and the surgeon must make way for this important phenomenon. From this source, the adherent soft parts, the bone derives additional circulation and its healing and reconstruction are thus aided.

When I first tried Orr's technique, I applied it exactly, following the operative débridement and saucerization by careful swabbing of the wound with iodine and 95 per cent alcohol. But after I became convinced that d'Herelle's principle of bacteriophagy was largely responsible for the success of the treatment, I ceased using these powerful antiseptics, precisely as the grove men have done in their orange groves; because of the danger that chemicals may kill the beneficial parasite, or do more damage to it than to the pathogenic bacteria. Certainly if we are trusting to this active living agent to completely overcome the infection in our wound, why should we not view it in the same light as we do the lady beetle and red-headed ray fungus?

D'Herelle states that the phenomenon of bacteriophagy does not take place in the presence of antiseptics when the amount is sufficient to modify the state of the bacteria. One should, therefore, not use local antiseptics when bacteriophage is locally desired.

When saucerization and cleansing are complete, the wound is immediately packed with sterile yellow vaseline and gauze soaked in an excess of the same. Since this dressing is semi-fluid at body temperature, it readily insinuates itself into the most remote recesses of the wound. The packing is allowed to overflow the wound so that it covers an inch or more of skin on either side. It is then covered with a gauze dressing and cotton padding, after which the limb is encased in plaster, and the joints above and below thus immobilized. No window is cut. The dressing is left intact for eight to ten weeks, at which time it is changed and reapplied after simple cleansing, unless the wound is entirely healed. This procedure is repeated until healing is complete. Sometimes the plaster is omitted at the second or third dressing, if healing is well advanced.

I previously[9] suggested that some principle is retained in the wound by this method of dressing, which will, if undisturbed, contribute materially to the destruction of the infecting organisms. It is probable that this consists in part of the antibodies and living phagocytes; but the further suggestion was made that the specific bacteriophage accumulated in the wound if it was not dissipated too rapidly by irrigation or frequent dressing. There are thus two causes which may be suggested for the phenomenal results produced by this new method of dressing; one is mechanical and physiological, and the other is concerned with those newer principles of bacteriology which have to do with the nature and action of the bacteriophage.

After adopting the premise that a bacteriophage could be demonstrated in the wound after it had been enclosed in a dressing for some weeks, we conducted research to discover whether such bacteriophage was specific for any or all of the infecting organisms, and whether and to what extent the character of that organism was changed in the presence of the phage.

This work was conducted in the laboratories of the Post-Graduate Medical School

with the cooperation of Dr. Ward MacNeal and Miss Marjorie Patterson.

BACTERIOLOGICAL PROCEDURE

Pus obtained from the wound at operation or at subsequent change of plaster dressing was sent to the laboratory for culture examination. The visible bacterial flora were determined and a record made of the relative numerical predominance of the organisms present. The strains occurring in largest numbers were thought to be of some etiological significance in chronic osteomyelitis with which the host must cope for long periods of time and were, therefore, worthy of study. In a search for the presence of a lytic agent which might account for the clean appearance of wounds, it was first necessary to determine the susceptibility or resistance of these strains of bacteria to lytic action. This was done by subjecting them to the action of suitable stock races of bacteriophage of high titer. The fermentative reactions of organisms under study were determined at each examination as one means of identifying the same strain, or of ascertaining biochemical changes which might be brought about by environmental conditions in the wound. Broth cultures of the wound pus after twenty-four hours' incubation were filtered through Berkefeld N filters, and these bacteria-free filtrates tested for the presence of native bacteriophage. Since d'Herelle has shown that strong lytic principles isolated from the human intestine in health and disease may show action against few or many of the bacteria constituting the flora, known susceptible strains of the species corresponding to those present in the wounds were employed in addition to the wound strains in an effort to demonstrate readily the presence of lytic agents in these filtrates.

The excellence of the results makes this new method of wound treatment unquestionably preferred by all those who have experienced its advantages over former methods. Not the least of these is its simplicity which results in economy of both patient's and surgeon's time, and of the former's money. In these days of "depression," one is duty-bound to consider the economics of medicine. Instead of remaining in the hospital for weeks or months after operation while repeated Dakin irrigations are carried on several times a day, the patient may leave the hospital in a week or ten days after operation. He can remain at home several weeks in congenial surroundings, free from the worry of hospital bills. When he returns for removal of the cast, the time required is so short and the reaction so slight that he need remain in the hospital only overnight, or in some cases only a few hours. Between visits, the surgeon's time and the hospital bed are free for another patient, an important consideration in any busy institution.

How markedly hospitalization is decreased by bacteriophage treatment is illustrated by a case of osteomyelitis recently referred to us from Baltimore. There the patient had been in the hospital for one hundred and five days under the maggot treatment, which failed to bring about healing. It is well known that the longer a case of osteomyelitis persists, the more difficult it is to treat. In this case we had to reoperate and do a fresh débridement and sequestrectomy before applying the bacteriophage dressing. Yet this same patient was hospitalized a total of only ten days from the time the first vaseline dressing was applied until the osteomyelitis was completely healed,—eight days after my operation and one day for each successive dressing.

To the surgeon about to repair the bone damage in an old gunshot wound with a history of infection, or any bone wound with such a history, re-alighting of a latent infection is his greatest fear. After any successful germicidal treatment, a little colony of bacteria may remain encapsulated in the tissue, quite harmless until the surgeon's knife unwittingly releases them. With what fiendish glee these

microscopic demons must watch the surgeon complete a meticulous piece of reconstruction, knowing that as soon as his back is turned they will start their irreparable havoc. The Dakin solution, because of its content of nascent chlorine, surpassed earlier germicides in reaching bacteria in recesses of the wound. But it did not always find them all. In bacteriophage we have for the first time an active *living* agent, seeking out these minute tissue destroyers in nooks and corners just as ferrets hunt down rats in an infested house. If poison is used, one is not sure that all the rats will find it and die as a result. Some are likely to escape and breed again. But ferrets, if left to pursue their hunt for a sufficient time, will rid the house of every rat. Will this active living agent, bacteriophage, in a similar way do away with latent infection? It is too early to say; but the fact that it lives and reproduces as its feast of bacteria progresses gives the surgeon hope that this may prove true. Certain it is that time is an important factor in the successful application of bacteriophage treatment. Shut up eight weeks to fight its battle beneath the cast, the phage has a good chance to achieve so certain a victory that the danger of future bacterial revolutions seems less likely.

Under such dressings, the phage develops spontaneously in about 94 per cent of cases of wound infection. The worse a wound being treated by bacteriophage smells, the better it may be doing. Sometimes patients beg to have the cast taken off because it stinks so,—a perfectly natural reaction, they think their wound is going bad. Instead, the wound granulations are growing more and more healthy. Indeed sometimes when the first cast is removed, the wound is practically healed; and to the surgeon who has seen the excellent results of this treatment, the foul odor is sweet.

Julian Huxley, the eminent British scientist, has recently commented[14] on the elaborate system of checks and counter-checks by which Nature maintains its balance, and on the way in which man can use this same system to protect his interests and control his environment. Thus in Figi, where the valuable coconut industry was threatened by a little moth who devoured the leaves of the palm trees, biologists searched the remote corners of the Pacific for a parasitic fly. This fly quickly reduced the menace to the status of a minor nuisance.

By other anti-pest organisms of Nature's creation, the sugar cane of Hawaii has been saved from its weevil destroyers; and massed battalions of lady-birds are successfully attacking the mealy-bugs which threatened the existence of Kenya coffee.

In my own citrus groves in Florida, as already related, I have often made use of a living parasite to protect the trees from destruction by the purple scale. This method of grove preservation is identical in principle to that which I have evolved in the treatment of infected wounds.

These few examples merely hint at the control of his macroscopic environment which man is exerting to an ever increasing degree. How great that control will become in the future we cannot prophesy. But, as Huxley says: "What grows on any part of the land's surface will grow there because of the conscious decision of man; and many kinds of animals and plants will owe not merely the fact that they are allowed to grow and exist, but their characteristics and their very nature to human control."

He speaks of Macroscopia. As amazing checks and counter-checks go on in Microscopia where bacteria wage their wars, and in Ultramicroscopia where the surgeon's new ally, bacteriophage restores healthy balance to infected tissues. Thus from the highest to the lowest organisms, and in every kingdom of the universe, Nature carries on her fascinating counterplay.

[For References see p. 247.]

SOME OBSERVATIONS ON OSTEOMYELITIS*

ISIDORE COHN, M.D., F.A.C.S.

NEW ORLEANS

DESPITE the great number of papers which have been written on the subject of osteomyelitis with reference to early diagnosis, it is rarely diagnosed early. All authors reiterate the formula by which a diagnosis can be made, yet few have the good fortune to present many personally observed real acute cases which they have treated. This sad commentary is responsible for the presentation of this collection of personal experiences for consideration here.

Didactic teaching and textbooks must of necessity be dogmatic in a measure based on ideals not yet attained. This is especially true with reference to the disease under consideration.

In this discussion an effort will be made to present the state of the development of the disease process when the individual cases first came under my observation. In one instance to be cited the patient was under the observation of a competent physician for two weeks. During that time a discussion of the *x*-ray finding delayed surgical intervention until a positive blood culture was obtained. In another instance a pathological fracture, secondary to osteomyelitis, prevented early recognition and proper handling. The diagnosis of pleurisy, pneumonia and of tonsillitis in other instances delayed early recognition of the disease.

I think all will agree that this evidence indicates that efficiently early diagnosis is the exception rather than the rule. I believe that the evidence indicates that operative procedures which are at times resorted to are incomplete, and that dangerous operative methods of approach which increase the risk to important vessels are too often adopted.

I am sure, when one considers treatment, that it is not necessary to adopt one of the recent ideal methods of treatment in order to obtain good end-results. I do not hold as true—once osteomyelitis, always osteomyelitis.

In order to develop the thesis only certain phases of the broad subject under discussion can be presented.

Diagnosis in very young children is at times greatly delayed. This is accounted for by the fact that painful extremities are often considered to be due to rickets, scurvy or syphilis, and many times the *x*-ray findings confuse rather than aid the attending physician. Of course it must not be overlooked that any one of the diseases mentioned may be coexistent with an acute osteomyelitis.

The following summary of 2 cases will serve to illustrate the point in question:

CASE 1. R. M. T., aged two months. The child had been ill for ten days before the mother noticed the swelling of the wrist. There was marked tenderness about the wrist, and the child did not use the arm with as much ease as she did the other extremity. The doctor in charge of the patient had *x*-ray pictures taken. These showed a destructive lesion associated with some productive changes. The pictures were variously interpreted; syphilis, scurvy, tuberculosis, osteomyelitis and malignancy were considered. The radiologist suggested that there was a well defined luetic process, and probably a mixed infection producing an osteomyelitis.

Several days later I was asked to see the child. At the time of my first examination, July 12 "the left forearm was larger than the right. The skin was slightly glossy, and red. Supination was limited. There was some infiltration of the soft tissues, both on the dorsal and volar surfaces of the forearm, and I got

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the impression that there was an irregular enlargement of the radius. There was no limitation of motion in the wrist, elbow or shoulder.

Fig. 1. R. M. T., July 12, 1929. Radiologic diagnosis luetic ostitis and probably a mixed infection producing osteomyelitis. No. 84939.

There was no glandular enlargement. I would be inclined to believe, because of the destructive reaction of lesion and infiltration, that we are dealing with an acute infection producing a destruction of bone. I believe that at least an exploration of the radius is indicated and advise that an exploratory operation be done."

The doctor, whose patient the child was, believing that the entire condition was due to syphilis, ordered antiluetic medication and orange juice. Surgical intervention was not accepted.

A blood count, ten days after the child was first seen, was 13,000. The Wassermann reaction was three plus. The child's fever persisted. Subsequent *x*-ray pictures showed marked increase in the destructive process.

Twelve days after the child was first observed a *blood culture showed a positive hemolytic staphylococcus. Twenty days after the first observation* we were permitted to operate upon the child. We found the radius on both sides diseased and a pure culture of Staphylococcus aureus was obtained *from the pus.*

This child made an uneventful recovery.

Fig. 2. R. M. T., July 22, 1929. Picture indicates progress of disease. No. 85120.

The *x*-ray pictures (Figs. 1–4) which are here presented show the marked improvement which followed. The child was last seen one week ago (May 28). The condition is excellent.

Case II. H. H., aged three months. Breast-fed baby. The following history was obtained. The mother noticed that the baby cried when the right leg was handled, and that the baby held the right leg and thigh flexed. Temperature was 102.5°F.

Examination of the right leg showed a marked swelling causing the leg to have a fusiform shape between the knee and the ankle. The skin over this area was tense and shiny. There was no fluctuation. Movement of the leg caused pain. The other leg and arms were free from evidence of deformity or involvement.

The *x*-ray findings were reported as follows: "There is a fracture of the tibia in the upper

third. There is a marked periosteal reaction which is characteristic of lues."

The doctor who first examined the baby specifically stated that he did not think it a case of osteomyelitis. Anti-luetic treatment was ordered for the patient.

Fig. 3. R. M. T. August 13, 1929. Two weeks after operation. No. 85549.

Four days later, when I first saw the child, the following notes were made. "The right thigh is flexed on the abdomen, and the knee flexed at a right angle. External rotation and abduction of the entire lower extremity. The leg and thigh on the right side are larger than on the left. There is some glossiness of the skin of the leg and foot. Palpation over the leg causes the baby to scream. There is an apparent thickening of the inner side of the shaft of the tibia. I believe that there is a slight fluctuation in the center of the mass. There is some edema of the thigh. The head of the femur rotates with the shaft. The deep femoral glands are enlarged. I believe that this is a case of osteomyelitis and accordingly advise operation."

Immediate operation was done. A subperiosteal abscess was incised and drained. The cortex of the tibia was removed for ¾ inch. Pus was found in the medullary canal.

Prior to operation an *x*-ray picture was taken and an osteomyelitis was reported as being present. A coincidental luetic change was considered to exist.

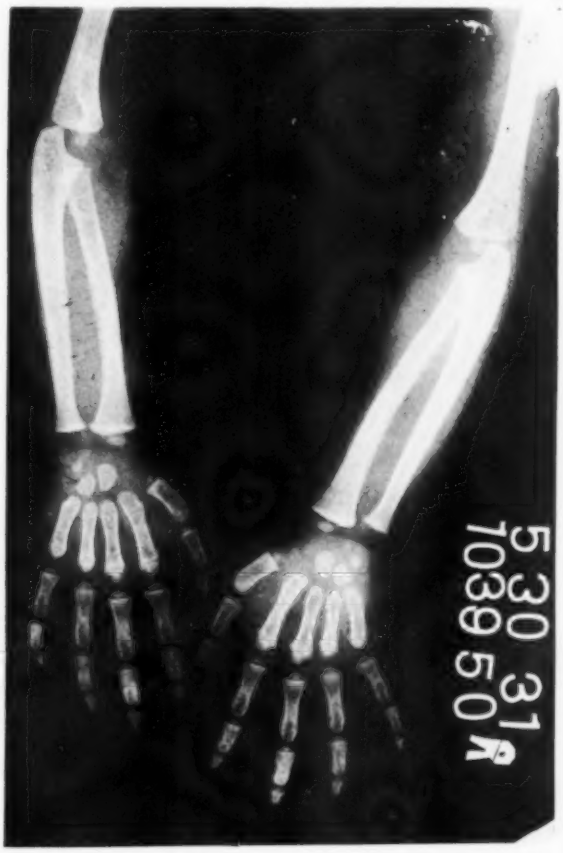

Fig. 4. R. M. T. May 10, 1931. One year and nine months after operation. No. 103950.

X-ray pictures taken May 31, 1931 show a progressive improvement of the previously shown disease of the bone. There is almost a complete return to the normal appearance.

Comment: In these cases the clinical findings suggested osteomyelitis, the *x*-ray findings were variously interpreted. Syphilis was suspected and the idea persisted for over two weeks before surgical intervention was allowed. It is true that from the radiological standpoint there was good reason to state that the patient had congenital syphilis. In view of the recent observations made by MacLean, February 1931, the confusion in such a case would certainly

be increased for he states there is almost a unanimous opinion that in infants during the first weeks of life a deepening in the

Fig. 5. D. T. Osteomyelitic focus in lower portion of diaphysis.

longitudinal axis of the provisional zone of calcification of the long bones is indicative of syphilitic involvement. He also states that there is usually a rarefaction near the metaphysis; further that syphilitic osteomyelitis can be definitely diagnosed "roentgenologically" if the osteomyelitic lesions are symmetrical, and further that lesions are usually punched out areas with thickened contiguous supportive periostitis.

In Case I of this series the *x*-ray pictures presented all of these evidences. The patient did have congenital lues, but the patient did not improve until the osteomyelitic foci, which were proved to contain Staphylococcus aureus, were surgically drained. Moreover, the patient did have a positive blood culture prior to operation. In both instances the diagnosis of osteomyelitis was confirmed at operation. The rapidly progressive destructive nature of the lesion indicated an acute bone infection. Much valuable time was lost in both cases because the classic picture was not present. It must be remembered that an infant cannot locate his pain for us, that gross differences in the size of the affected limbs may not be found and that syphilis, scurvy and rickets may be present in association with osteomyelitis. A pathological fracture such as was found in the case described here may coexist with osteomyelitis.

If we are to prevent prolonged illness, great destructive changes and crippling deformities, we must not wait in the case of infants. Early operation is comparatively easy, takes but a short time and the period of after care is greatly shortened.

Can we agree that too much has already been said on osteomyelitis and the need for early diagnosis when one sees cases such as the following:

Case III. Master D. T., aged nine years. When the child came under my observation about two weeks after the onset of the disease the following history was obtained. The child had developed pneumonia three days after having played football on a wet lot. He had high fever and pain in his chest and abdomen. After the child had been sick for about forty-eight hours a doctor was called and a diagnosis of pneumonia was made. Three days later the patient had sudden severe pain in the right thigh and leg. *X*-ray pictures were taken and an operation was done on the leg under local anesthesia. *Some pus was evacuated and the crisis of the pneumonia safely passed.* A few days later the doctor told the mother that he would have to open the leg and scrape the bone. At this time the child came under my observation.

The child presented the appearance of one exhausted by sepsis (marked emaciation, anxious expression, hot dry skin, rapid

shallow respiration and a rapid thready pulse).

We found a marked swelling of the entire right leg from the ankle up to above the knee.

X-ray pictures at this time (Figs. 5, 6) showed a marked destructive process involving the upper third of the diaphysis of the tibia.

Immediate operation was done. We found that the upper 2½ inches of the diaphysis of the tibia was so honeycombed that we felt that the best thing to do was to remove that portion of the tibia at once. With a motor driven circular saw section was made about 2½ inches below the upper limit of the diaphysis. The cavity was packed. We also found that there was an osteomyelitic focus in the lower portion of the diaphysis of the tibia on the same side. With a motor drill we entered the medullary canal and there found evidence of diseased bone and a small quantity of pus. Dichloramine-T pack was introduced and a plaster cast applied.

The child's condition was so precarious that it was necessary after a few days to give him a transfusion. His convalescence was stormy, but his eventual recovery was excellent as evidenced by the pictures which show the marked regeneration of the tibia which has taken place.

A year later the child returned with pain over the wrist. We found evidence of an osteomyelitis of the os magnum, or capitate. The entire diseased bone was removed. The child made an uneventful recovery. He has not had to have, so far as I know, any subsequent operative procedure.

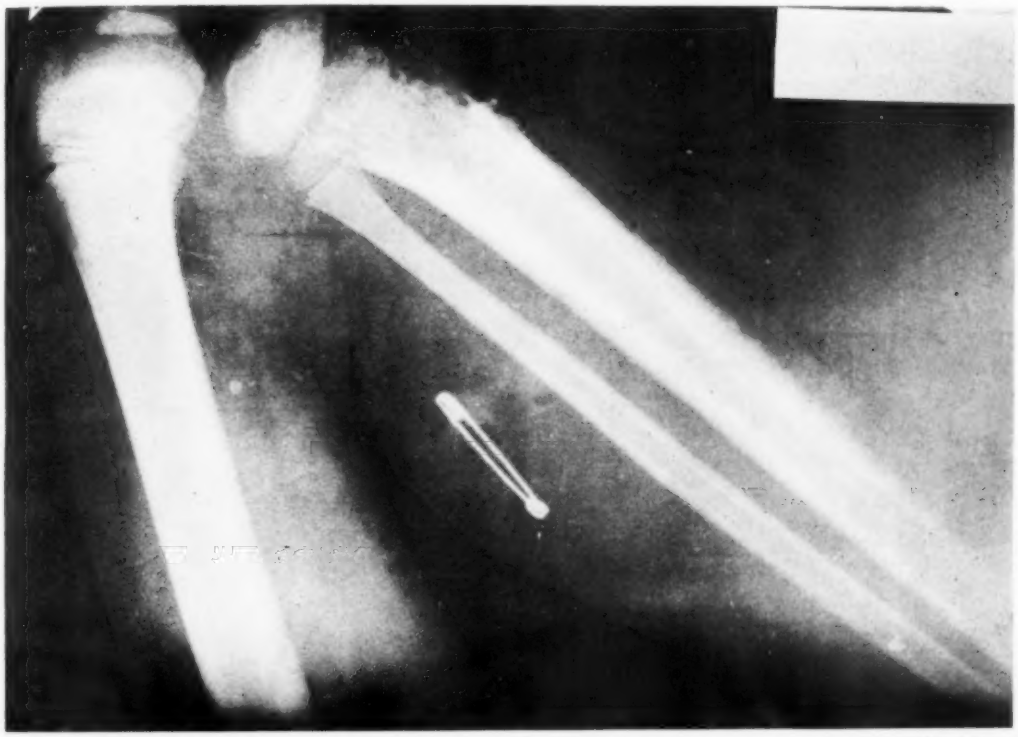

Fig. 6. D. T. Before operation, showing destruction of the upper portion of the diaphysis.

Case IV. Master J. T., aged nine years. The child was first seen on the July 17, 1930. His illness began in November 1929, with an acute febrile reaction and pain in both lower extremities. For two months he was kept under observation because his tonsils were diseased. At the end of that time the tonsils were removed. The child continued to run temperature and this had been considered to be due to rheumatic fever. *In June 1930 the family insisted on having x-ray pictures* of the extremities because the child continued to complain of pain. The picture showed evidence of disease of the neck of the right femur and the lower portion of the left femur. The doctor who was in charge at the time operated on the child, making a drill hole in the shaft of the femur below the great trochanter. At this time

an incision was made on the inner aspect of the left thigh, about the middle third. His temperature persisted.

Fig. 7. D. T. January 12, 1928. Osteomyelitis of os magnum (capitate) which was removed. Patient has been perfectly well since. No. 8395.

On July 17 the child was brought to New Orleans and was referred to Dr. Butterworth through whose courtesy I had the opportunity to see the patient. We found a tilting of the pelvis. The right thigh was much larger than the left. The right lower extremity was apparently longer than the left. We found an incision on the inner side of the left thigh above the knee in which we found a pack.

X-ray pictures were taken, blood count, and blood culture. The pictures demonstrated a progressive destruction of bone, involving the neck of the right femur with a proliferative osteitis. Just above the great trochanter the cortex had been broken through. There was evidence of a drill hole below the great trochanter.

Fig. 8. D. T. June 14, 1928. Eight months after operation. Showing bone regeneration. No. 76210.

The white cell count was 19,400.

It became necessary, because of the destruction of the trochanter and neck, eventually to remove all of the trochanter, neck and head of the femur. It was also necessary to operate upon the left femur where there was an osteomyelitic focus in the lower portion of the shaft. The subsequent course of this case which is still not a cured case by any means, has been stormy. During his stay in the hospital the

child developed an acute appendicitis for which it was necessary to operate upon him. Later the retroperitoneal glands became involved, he developed a septic endocarditis, and at the present time is still running temperature as high as 101°F. For months his temperature ran as high as 103–104°F. daily. Several transfusions were given.

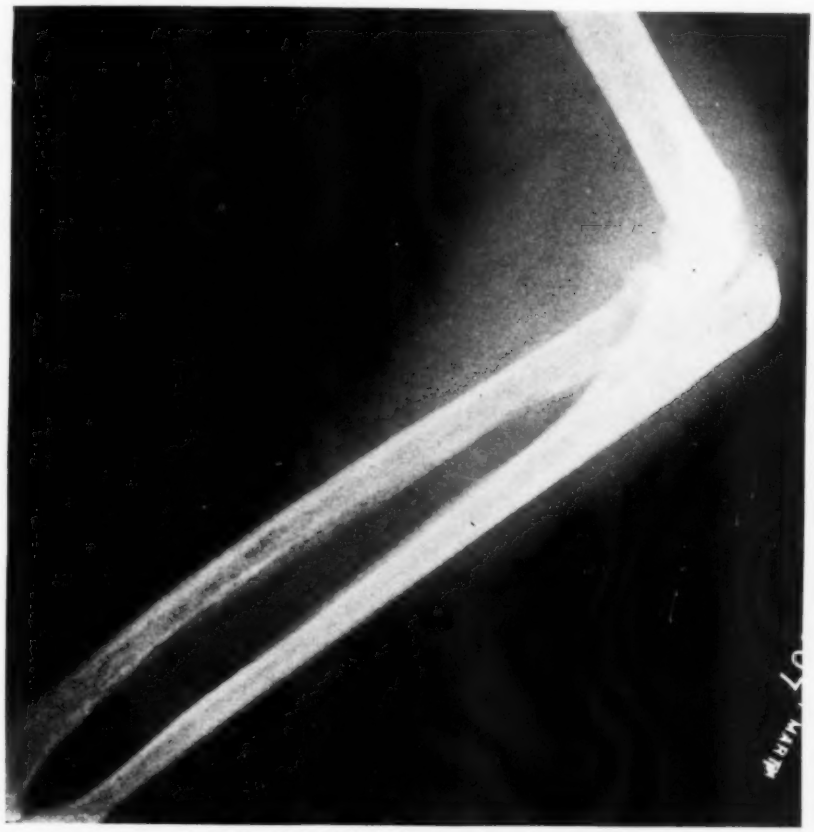

FIG. 9. Mr. O. B. Showing extensive osteomyelitic involvement of practically entire radius except lower third of diaphysis. September 13, 1929.

This child will be, if he survives, a terrible cripple. An early diagnosis, and proper surgical intervention probably would have cured this child in a very short while. Instead he represents one of the human wrecks which stand as a monument to late diagnosis, and as mute evidence of the great destruction that can be produced by osteomyelitis.

In summary then we see two tragic results which followed a diagnosis of pneumonia, and of tonsillitis. We witness, by the examination of these two patients, the ravages that septic processes will produce. In both instances the profound anemia and the sepsis did look as though there would be a tragic end. It is true they gave us an opportunity to see the beneficent effects of operation and transfusions. It also caused a great amount of undue anguish to the parents. Fortunately the first child has recovered and is well today. Early diagnosis and prompt surgical intervention would have cured both of these cases in a short while. Early diagnosis would have avoided extensive mutilating operations, and transfusions would not have been needed. The result in the first case indicates that regenerative processes will restore form and function.

The next case adds further evidence of the real need for early diagnosis.

CASE V. Mr. O. B. This patient was first seen September 17, 1929. Following is a brief summary of the history as I obtained it from the patient. Patient had pleurisy five weeks

before. Four weeks previous the left forearm began to swell. At this time an *x*-ray was taken of the elbow because of pain and some swelling of the forearm. The picture showed no evidence of bone disease. After the first few days he was not confined to bed.

On examination, September 17, a diagnosis of osteomyelitis was made.

The patient was admitted to Touro Infirmary for operation. Prior to operation the median, radial and ulnar nerves were tested for their galvanic response. It was found that there was very little delay in the response. Prior to operation pictures were also taken. These indicated a destruction of almost the entire radius down to within about 1½ inches of the styloid process.

Operation was done and this consisted in a subperiosteal removal of the entire shaft of the radius except the lower 1½ inches. The operative record which follows is included because of the method of approach to the radius for a complete subperiosteal removal of the radius.

Fig. 10. Mr. O. B. One year and eight months after operation showing great amount of regeneration which has followed. Patient has never had a second operation. No. 104068.

"Operation: A subtotal excision of the radius. Position of forearm, elbow flexed at right angles; forearm midway between pronation and supination. Incision made beginning at the level of the head of the radius, and at a point posterior to the insertion of the supinator longus, extending foreward obliquely across the forearm, and to the middle of the forearm and then continued downward to the styloid of the radius. Muscles were separated. Intermuscular planes found, radius exposed subperiosteally, bisected about the middle and with a lion-jaw forceps the upper fragment including the head was removed. Pack intro-

duced. Lion-jaw forceps applied to the lower fragment. It was decided, however, not to remove the entire lower fragment, but to leave the base of the radius with the hope that in that way, a useful wrist might be obtained. When the fragment was removed, the periosteum had attached to it, a long involucrum, about ⅛ inch in thickness in some places and tapering down to about 1/32 inch. Dichloramine-T pack was introduced and interrupted sutures were applied over the pack. Skin was closed with interrupted dermol sutures. Plaster cast applied, elbow at right angle, the hand was included, wrist in a cock-up position, or dorsiflexion."

The convalescence in this case was unusually smooth and the picture (Fig. 10) shows an amount of regeneration which had taken place up to the last time that the patient was seen.

June 3, 1931. Since last seen his arm has given him no trouble. The only thing he has noticed is that the arm has *become stronger*. He is able to drive an automobile. There has been no pain whatsoever.

Examination on this day revealed the left forearm to be smaller than the right. There is a slight bowing on the radial side. There is a scar which extends from the level of the external condyle obliquely downward to the styloid of the radius. The scar is about ¼ inch wide.

The patient is able to flex to slightly beyond a right angle and extend it about 150 degrees. Pronation is complete, supination to about 60 degrees. There is no limitation of motion about the wrist. The grip is excellent.

Comment: In this instance the patient was treated for a pleurisy. One week after the onset of the fever pain and swelling of the forearm attracted attention to the forearm, but since the *x*-ray picture did not reveal any evidence of disease nothing further was done. After another three weeks had elapsed a second picture was taken. It was then that I had the privilege of seeing him.

A radical operation had to be done. The entire radius, with the exception of the lower 1½ inches, was removed superiosteally. Regeneration progressed very rapidly. No subsequent operations have had to be done.

Mention should be made of the method of approach. It has been my policy to follow the suggestions of the late James E. Thompson in the approach to all long bones. In this instance the forearm was kept midway between pronation and supination with the elbow flexed at right angles. The incision began at the level of the head of the radius, and at a point posterior to the supinator longus, extending obliquely forward across the forearm and then continuing down to the styloid of the radius, where we were thus able to get in the intermuscular planes. The radius was exposed subperiosteally. In order to avoid a great deal of dissection and damage to the soft tissues the radius was bisected about its middle, then with a lion-jaw forceps it was easy to remove the upper fragment, including the head. The remainder of the operation has been already described.

In the method utilized we were able to avoid extensive damage to muscles and important nerves, particularly the radial nerve. In the postoperative management of the case we were able to give the patient considerable comfort by having a moulded leather jacket made for the lower third of the arm and the entire forearm. I believe that all will agree with me that delay in diagnosis resulted in extension of the disease and necessitated an unnecessarily radical operation at a later date. Early diagnosis would have caused less disability, less pain, and less expense to the patient.

We talk of reducing mortality and morbidity in cancer, appendicitis, and osteomyelitis, and yet such calamities as these are mute evidence that our progress toward the goal is slow if at all sure. Too much dependence is still placed on *x*-ray pictures.

In the two preceding cases attention has been called to the regeneration which has taken place in these patients. Recently it has been my good fortune to see a patient on whom I did a complete superiosteal resection of the diaphysis of the tibia fifteen years ago. At the present time

there has been not only a complete regeneration, but the form of the tibia has been restored. This case presents so many

Fig. 11. Miss H. V. Fifteen years after subperiosteal excision of entire diaphysis of tibia. Patient has never had any further operative procedure. No. 102211.

interesting features besides the satisfactory regeneration, that a brief summary will be included.

Case vi. Miss H. V. White female, aged eleven years? Patient originally presented herself to a surgeon who drained a subperiosteal abscess about her ankle. Five weeks later the patient came under my observation. At that time there were a number of draining sinuses on the inner side of the leg. *X*-ray pictures taken at this time revealed the fact that the tibia was honey-combed from one end of the diaphysis to the other. A subperiosteal resection of the entire diaphysis was done. This patient has not needed another operation.

The original operation was done fifteen years ago. At the present time an *x*-ray picture (Fig. 11) shows a fully regenerated tibia. A synostosis has formed between the tibia and the astragulus, but in spite of this the patient dances, walks and carries on generally without discomfort. All of her ankle movements are accomplished through the astragalocalcanean articulation.

The method of treatment utilized for the past eighteen years has been consistent. In the few cases in which a real acute condition has been found, at the time that the patient has come under observation, the following method has been utilized. A diagnosis is made in those cases which present a history of an acute febrile onset with pain as a rule localized over the shaft of one of the long bones. There is usually a marked leucocytosis. *X*-ray is not depended upon for diagnosis. The *x*-ray can be of service only when the disease has existed long enough for destructive changes to have taken place. Under no condition can the *x*-ray give definite information unless there is a difference in the density of the various portions of the bone involved. I believe that it is better to err when no osteomyelitis exists, rather than to delay and wait for definite *x*-ray changes.

Under general anesthesia an incision is made through the periosteum and a number of drill holes are made through the cortex, and if the disease is in that portion of the bone above the cancellous end of the diaphysis, into the medullary canal. Two points which I should like to emphasize right here are (I) that the presence of pus under the periosteum indicates that the operation should be extended to include drainage of either the cancellous portion or the medullary portion of the bone, depending upon the location. It cannot be emphasized too often that all pus outside of the cortex must have gotten there in a centrifugal manner. Drainage is the essen-

tial thing. The type of drug applied which is used is almost immaterial. With free drainage it matters little whether dichloramine T or vaseline, or anything else is used. The advantage of an oily substance on the gauze is that it does not become adherent to the endosteum.

By way of digression I should like to insist that in acute osteomyelitis a curette should never be used because with the curette you destroy the very cells on which you are depending for regeneration. There is also a grave danger of injuring the nutrient artery, and if a clot is formed you are likely to have the entire diaphysis sequestrate. The application of a plaster cast has been our practice.

In later cases the amount of bone to be removed is dependent on the amount of evident disease. After the cavity has been loosely packed with dichloramine T (since 1917) the pack is usually allowed to remain for five days, after which it is removed. If the pack is not removed the supply of dichloramine T has been replenished.

The Orr method of treatment does not seem to me to meet surgical principles. While many are willing to accept the method, it does not appeal to me. The secretions which do accumulate irritate the skin and after a time the odor which emanates from the dressing is nauseating. With more frequent change of dressings there is less likelihood of concealed damage occurring.

It is not my intention to enter into a controversy with those who prefer putrefactive odors due to unchanged dressing, or with those who stand by and expect healing processes to be promoted by living scavangers in the form of repulsive maggots as advocated by the late Dr. Baer. Let me hasten to add that Bear did obtain good end-results by the use of sterilized well bred maggots; so do the followers of Orr, and so have we. The results are dependent more on the factor of prompt drainage of the infected and devitalized bone, than on anything else. The amount of destructive change is directly proportionate to the location of the embolus, and to the promptness with which drainage is instituted.

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* Continued from p. 236.

A FURTHER CONSIDERATION OF

RADIUM & SURGERY IN CANCER OF THE BREAST*

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IN 1922, I read a paper advocating the use of *x*-ray and radium combined with thorough surgical removal, in cancer of the breast,[1] in other words, a radical operation after the method of Halsted and others, with radium and *x*-ray irradiation added. This method was suggested to me after a careful study had been made of what radium and *x*-ray irradiation would do, independently of surgery, in the treatment of cancer.

The best surgery done by the best surgeons in all parts of the world, results in about the same percentage of cures. The slight differences noted in the five-year cures reported, can be accounted for in the difference in classification of percentage of operability. Of course, the better and more radical the surgeon, the larger his percentage of operable cases.

Radical breast surgery has been so well developed that the mortality in the best hands ought to be less than 1 per cent. The peak of operative cures was reached sometime ago. Operative technique has been improved to such a point that some other agent must be introduced to give better results. The cautery technique, by either the electric cautery or the cautery knife, so-called, has contributed something, but even with these accessories surgery still needs help in order to materially increase the number of cures.

Earlier diagnosis has markedly increased the number of cures. Women have been so educated that they now go to their doctors earlier than they formerly did. Thus many patients are operated upon early enough to effect many more cures than formerly, even by surgery alone. This education of the lay public has advanced along with the improved operating ability of our surgeons. It deserves credit for some of the improvement in our five-year cures. This has been noted by various writers, and must always be borne in mind in making our estimates of the value of the various methods of treatment.

I have suggested that radium and *x*-ray have probably come to establish the Fourth Epoch in the surgery of cancer of the breast.

In my first paper on the subject,[1] I advocated planting the radium at strategical points at the time of operation. This method, so far as I have been able to learn by a study of the literature, was the first proposal to put the radium in at the time of operation, and as a part of the operative procedure. All existing methods of preoperative and postoperative irradiation consisted of applying radium or *x*-ray from without.

At that time, however, some users of radium did introduce needles into such growths of the breast as were regarded as inoperable. Boggs of Pittsburgh, advocated this method, and I presume there were others who did so. In December, 1927,[2] Handley of England, proposed planting radium as a part of the operative procedure. In May, 1929, I again presented a paper, advocating the use of radium and *x*-ray as adjuncts to surgery in cancer of the breast.[3]

I am venturing to emphasize again the use of radium as a part of surgery of the breast. I am doing so with a greater degree of confidence than formerly, since the method I originally proposed is being advocated in various parts of the world, and discussions of the method by high authorities have been appearing in medical journals since 1927, the latter date being the earliest I have noted. I actually began

* Read before the Southern Surgical Association, Lexington, Ky., Dec. 9, 1930.

the use of radium in 1919, making it a part of my operative procedure, basing my reasoning upon the following grounds:

quit talking about the "crab-like structure," which expression has unfortunately burdened the profession for so many years,

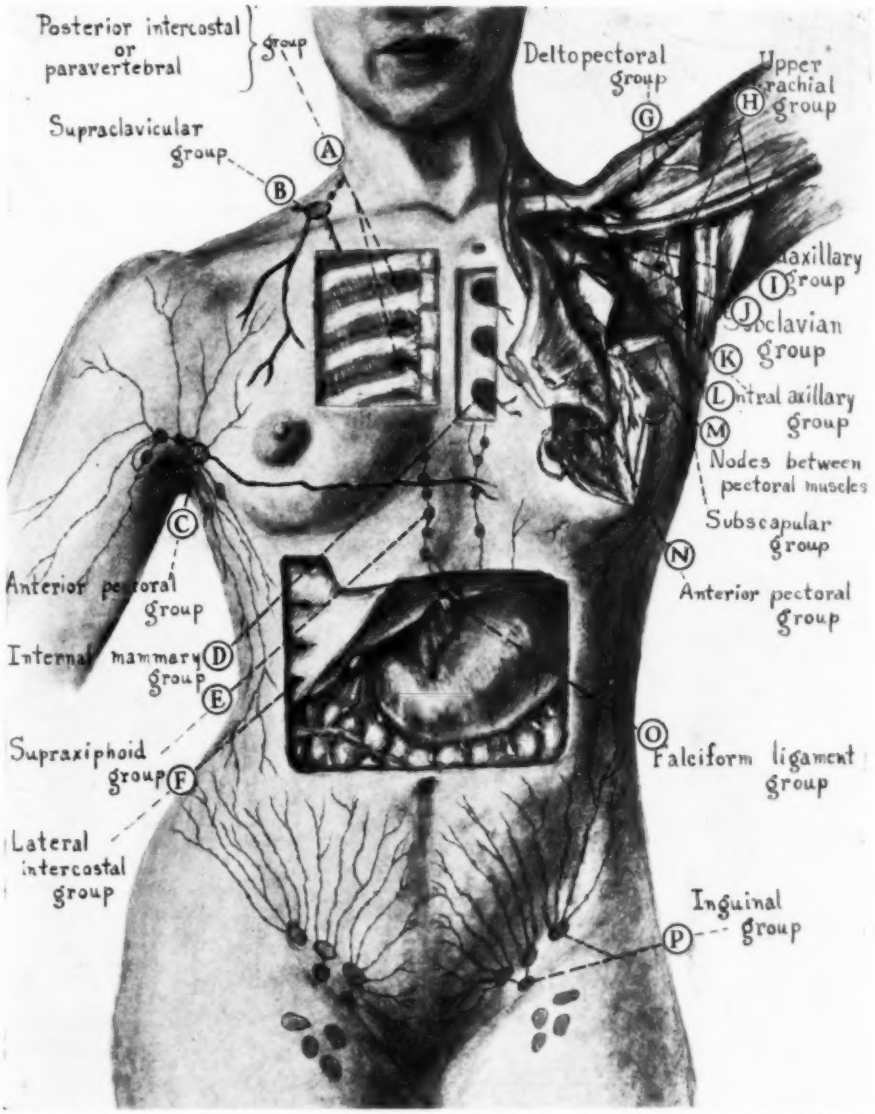

Fig. 1. Diagram showing lymph nodes of the breast and the lymph system with which they communicate. (Adapted from Deaver and McFarland's "The Breast and Its Anomalies," Blakiston.)

1. Surgery of the breast had reached the limit even in the hands of thoroughly competent surgeons. The peak of operative results had been reached and the average of cures by surgery could be improved chiefly in two ways:

(a) By the better education of the profession as a whole concerning the removal of lumps of the breast before they reach the stage of unmistakable cancer. Let us and think in terms of malignant growths that are "finished" when taken completely away by any method found harmful and mutilating to a minimum extent. There is still much faulty teaching in our medical schools, textbooks and journals, concerning the diagnosis of cancer of the breast. When we get to thinking of lumps in the breast as potential cancers and remove them, we will make decided

advances. I have heard the best clinicians discuss the fine differential points between malignancy and non-malignancy of the breast only to feel that I had received no information of value in the diagnosis of early cases. Then some clinicians give valuable information when the well-advanced cases are discussed. In my earlier days, I felt that these teachers had wonderful, even occult powers, but with experience and training in handling early cases, the conviction has come that occult powers are not possessed. Only a fair guess can be made by any of them, until the tumor is in the hand, cut out by that wonderful instrument, the "aseptic scalpel" which, as Deaver says, makes many a diagnosis. The time has arrived when we must regard every lump in the breast as possibly malignant, even though none of the classical signs of malignancy (retraction of the nipple, shortening of the trabeculae, and the consequent puckering of the skin and lymphatic gland enlargement) are present. Since these are late manifestations of the presence of malignancy, in order to avoid dealing with late cancer we must deal with the lump in its beginning, without hesitancy.

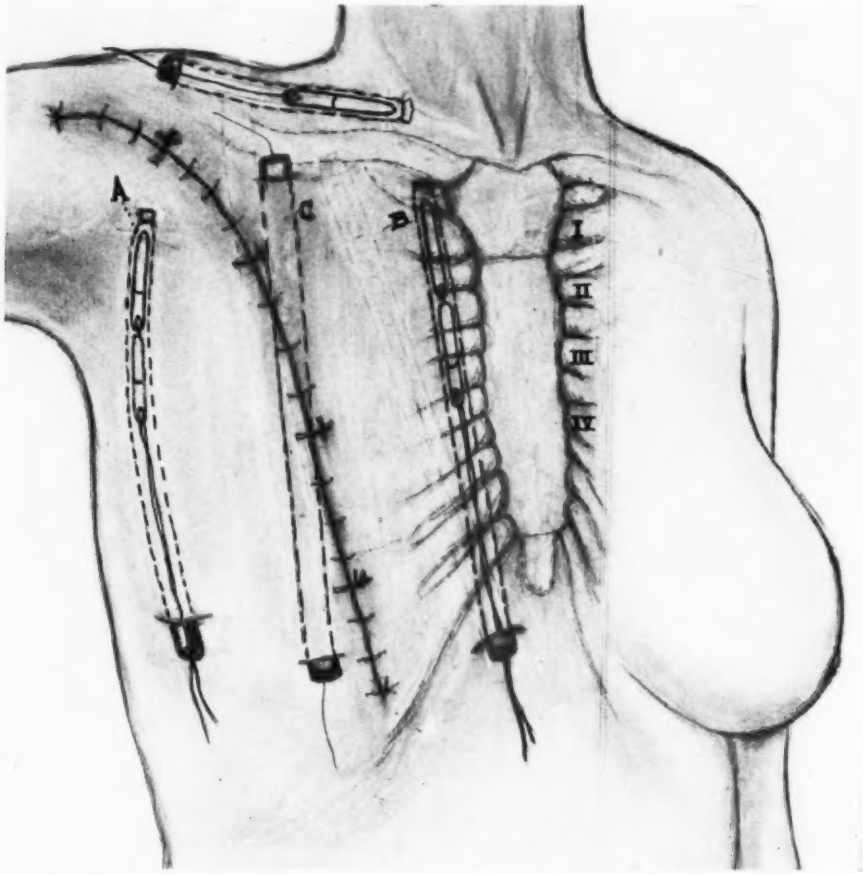

Fig. 2. Method as originally proposed in 1922 in applying radium. A and B, radium in position to be drawn down; C, tube in position through which radium may be drawn.

Surgeons must not be afraid now and then to make a mistake and remove a breast containing a non-malignant growth. This mistake must occasionally be made. Better to remove a breast containing a non-malignant lump than to leave a breast containing a cancer.

The surgeon must have at hand the means for diagnosing and classfying these growths in the operating theater at the time of operation, so that he may do a

conservative or radical operation, as may be indicated. Cutting out sections from growths for diagnostic purposes is dangerous, unless the section is made immediately.

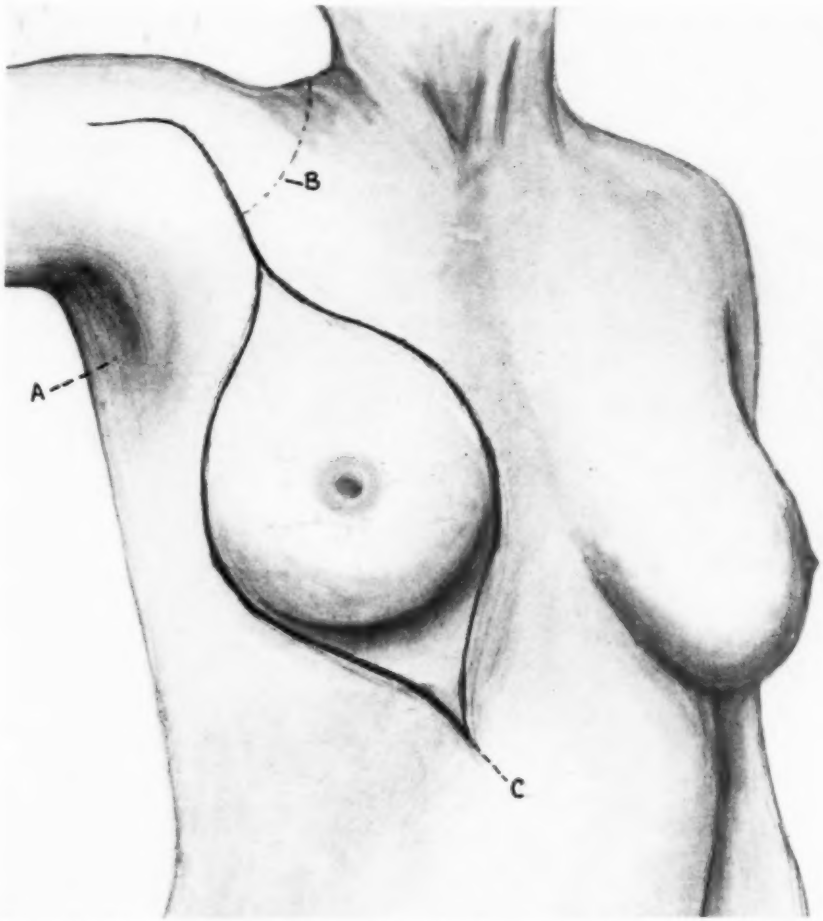

Fig. 3. Incision for radical breast operation. A, axillary glands; B, supraclavicular glands; C, epigastric glands.

(b) The better education of the people through the many avenues of public health work and through personal contact with the medical profession, will cause patients to seek advice before there are any "crab-like structures" which are incurable, many times. In this way, through surgery alone, the percentage of cures can be raised, and already it actually has been raised.

We are constantly confronted with patients who decline to take the advice of competent physicians as to the best treatment in any particular case. This is largely due to the great variety of opinions given by those physicians who are consulted. Some doctors are poorly informed as to what can be done in cancer, and are so pessimistic that the patient hesitates to do what the really competent physician advises. To many, a doctor is a doctor, regardless of how ignorant and incompetent he may be. We must teach women that a lump in the breast necessitates a visit to her doctor, and in turn we must teach her doctor that such a lump is better out than in; that more often than not, this is the only way such a lump can be definitely proved non-malignant. Failure to obtain this information may be fatal.

As the progress of education goes on, the public is learning how to determine who is and who is not competent, a hard lesson, but they are learning it; hence the surgeon

sees many early cases that are not only operable but curable.

2. I had observed that radium and *x*-ray radium into contact with the cancerous growths was one of the serious handicaps in its use. The skin not only interfered

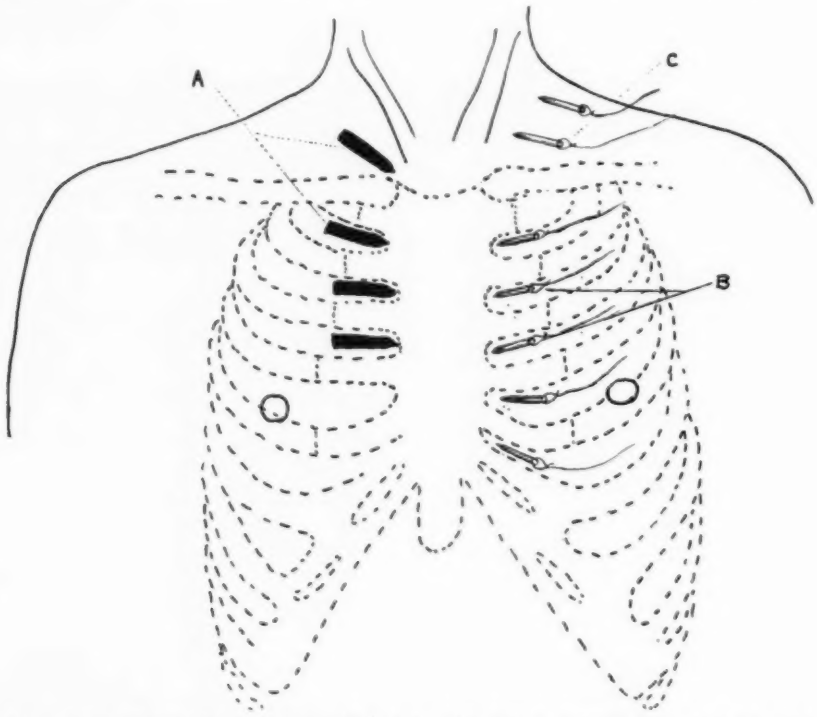

Fig. 4. Uses of radium. A, capsules of radium in place (after Handley, 1927); B, author's use of 10 mg. needles as practiced now; C, for supraclavicular region.

radiation were giving us some rather striking cures, even in seemingly hopeless cases. Kelly, Boggs, Pfahler and others, had exhibited such cases back in the days when some of our good surgeons poked jokes at them concerning their work. These pioneer advocates of radium and *x*-ray had succeeded by the use of ridiculed agents, in bringing past the five-year period some of the discarded cases of those same surgeons. Incidentally, some of the patients are now past the ten-year period, alive and well.

Having observed that surgery had apparently reached its peak of cures, even with its improved technique in careful dissection, by knife and cautery, and that radium and *x*-ray had demonstrated their potency in aiding and curing cancer, I began to strongly consider a combined method of surgery and radium radiation. It seemed to me that the failure to get the with the penetration, but it would stand only a certain amount of radiation. It was necessary to determine the amount of radiation, with certain filters, that the skin would stand, hence we came to calculate in terms of skin units, or what the skin would stand.

Finisterer of Vienna, whom I saw operating in 1913, while attending his clinic, attempted to surmount this difficulty by exposing the growth so that the *x*-rays could play directly upon the tumor. Recently, *x*-ray radiation of the operative wound before closure, has been advocated.

Thinking of Finsterer's method, I conceived the idea of putting radium directly into the tumor, after surgical exposure or, better still, to remove the growth as radically as possible by good surgery, and then place the radium at the most strategical points, for a sufficient period of time to

destroy cancer cells beyond the reach of the knife alone.

After operating in this manner upon quite a number of cancer patients, and finding that, apparently, the results were far better than by surgery alone, I hesitatingly read a paper before my State Society, as already stated, advocating the method. I have continued the use of radium, as proposed in this paper. I have carefully scanned the literature for reports of similar plans of attack. I may have overlooked some references, but I saw nothing of the sort proposed until December, 1927, when the report of Handley, already referred to, was published. This paper gave me much pleasure, for the author pointed out very clearly its distinct value in his own experience.

I have modified my original technique in keeping with the teaching of the Radium Hemmet of Stockholm and of Regaud of Paris, and of others who follow their methods in regard to the amount of radium used and the time of exposure, but I have adhered to the main plan of using the radium as an adjunct to surgery except in cases too far advanced for surgery. In such cases I have used buried radium needles and *x*-ray without surgery, which practically all surgeons now advocate as a palliative procedure.

I published a paper in 1929,[3] again advocating radium as an adjunct to surgical treatment, hoping thus to get others interested in the method.

In June, 1930, W. Turner Warwick[4] presented a paper under the title, "A New Technic Combining the Use of Surgery and Radium in the Treatment of Cancer of the Breast." He reports a series of cases and closed his paper by saying: "The series was reported because the results attained appear to establish the possibility of a more extensive attack on local and lymphatic spread by the combined use of surgery and radium then can be achieved by either alone." His method of applying the radium needles is certainly excellent. However, I do not agree that it is necessary to apply the needles along the entire intercostal spaces, as he does. His discussion of the principles upon which he proceeds is clear and to the point, and with these principles I agree completely. As his post-treatment observation period was only from December, 1928, to June, 1929, his cases could not be reported as cures. His method is almost identical with mine.

I am pleased to note that our own Hugh Trout,[5] has been using buried radium at the time of operation. He reported his work to the American Medical Association, November 1, 1930. His technique is practically the same as suggested in my original paper, in 1922. I vary this technique now, since acquiring radium needles, and will probably modify my method somewhat. Dr. Trout reports 22 per cent of his patients operated upon from 1909 to 1920 as alive and free from recurrences for five years, and this without radium. In 1920, he began placing radium tubes in the field of operation. This practice resulted in 30 per cent of five-year cures. In 1924 he added high voltage postoperative *x*-ray therapy producing apparently 55 per cent of five-year cures. These results, I believe, are in line with the results of others, but here again, confusion reigns, because there are so many factors that enter into any consideration of five-year end-results.

Confusion of mind reigns supreme when one attempts to analyze the pros and cons of the use of radium and *x*-ray in the treatment of cancer of the breast. Order, in a way, seems to be coming out of chaos as the knowledge of the use of these agents is more definitely worked out, and a more definite language is being spoken by the different writers.

F. W. O'Brien[6] suggests that until we establish and maintain tumor clinics where a common language is spoken, we will hardly be able to judge the comparative value of the different methods used in the treatment of breast cancer. We know that there is a definite trend toward a better appreciation of radium and *x*-ray in the treatment of cancer of the breast, and

there is a growing group of physicians who believe that surgery will be displaced by radium in the treatment of cancer of this organ.

Along this line, Geoffrey Keynes[7] of St. Bartholomew's Hospital, London, writes very strongly. He has worked out a plan of introducing needles after the method of Boggs of Pittsburgh and, in addition, uses a battery of needles in Columbia paste, which acts in a similar fashion to radium packs. He says: "I am persuaded that in the early cases, radium is the treatment of choice."

B. J. Lee,[8] of the Memorial Hospital of New York City, gives his conclusions as follows:

1. The treatment of carcinoma of the breast by irradiation alone, or combined with radical surgery, gives a higher percentage of five-year results than radical surgery alone.
2. Preoperative irradiation adds to the percentage figures of five-year results.
3. Postoperative irradiation has increased the five-year results.

I have searched the literature for the past ten years. It would be interesting to refer to many writers, but I cannot do so for lack of time. Much of the material is useless, save that it shows how great has been the struggle toward the solution of the problem.

I have become thoroughly converted to the use of radium as a part of the surgical procedure in operable cases of cancer of the breast. I have regarded all cases as operable that showed no general metastasis, and in which the patients were not too infirm either from age or disease.

The following was my original method:

Incisions for a radical operation were planned after the method of Halsted, Warren, Rodman and others, but most often that of Halsted was employed. Where the growth was not definitely cancerous I sometimes used an incision proposed by Warren, in which he went below the breast, removed the growth, and if it was found benign the breast was not sacrificed. This incision on the under surface of the breast is far less conspicuous and therefore more preferable when dealing with a benign lump. If the growth is definitely malignant, the radical operation is performed, removing the breast, axillary glands, areola tissue and pectoral fascia, en masse. If the growth definitely involves the fascia, as evidenced by immovability of mass and fixation to pectoralis major beneath, the pectoral muscles are sacrificed, along with the fascia covering the upper portion of the rectus.

I have not found it necessary to routinely sacrifice the pectoralis muscles, nor have I cared to remove them, as I think it pretty definitely proved that dissemination takes place through the fascial covering of the muscles. I have never seen the muscles involved by cancer, except by direct extension. There are those who claim to have found the muscle involved. I believe the fascia is the structure that is involved primarily, and then the muscle secondarily, by continuity.

Moreover, I feel quite certain that with my plan of irradiation all cancer cells will be destroyed by the radium. The presence of the muscle, I feel, is of some advantage, though not absolutely essential as a protection to the ribs where radium is so used. I think it well to meticulously clean the muscles of fascia, or remove them if involved, and then rely upon the radium to care for such cancer cells as may be beyond the reach of the scalpel.

The operation completed and all bleeding carefully controlled, radium is placed, as shown in the diagrams, keeping in mind the location of the lymph nodes, as shown in Figure 1. Figure 2 shows a rubber tube containing 25 mg. of radium element, screened by silver, brass and rubber. I have left the radium in position from six to ten hours.

Points 1½ in. apart are marked with silk ligature, so that the radium may be withdrawn a definite distance each six or ten hours, thus insuring careful and thorough irradiation.

It has been found that radium acts effectively for from 3 to 4 cm. through the tissues. Ten-milligram needles are placed in the intercostal spaces next to the sternum and about the middle of the intercostal muscles, and left there for from twelve to twenty-four hours. These needles definitely irradiate the internal mammary lymph glands.

One or two 10 mg. needles are placed in the supraclavicular space on the side involved.

A second rubber tube containing 25 mg. of radium, is placed beneath the clavicle, so that as it is drawn downward, as before described, the whole chest wall and the skin over the wound may be well irradiated. If the radium is left in each position for from six to ten hours, it will cause an erythema of the skin which later becomes brown. This latter sign is a good index that the area has been thoroughly irradiated.

CONCLUSIONS

This paper presents a plan of radium irradiation, to be used at the time of and in conjunction with surgery in the treatment of operable carcinoma of the breast.

I believe that radium, when employed as outlined, in conjunction with surgery, is far more efficacious in dealing with cancer of the breast than is the scalpel alone.

Unfortunate victims of breast cancer should, in addition to a thorough operation, be given the advantage of carefully planned radium irradiation at the time of the operation, and by such a technique as herein advocated.

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LEAD-ANTIMONY AMPULES CONTAINING RADON FOR IMPLANTATION IN CANCER*

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TWO types of tubes containing radium or radon are in common use for implantation in cancer, the removable and the permanent. Removable tubes, usually in the form of steel or platinum needles containing one or more milligrams of radium sulphate, have several objectional features, among which are the following.

It is difficult to determine the duration of time that removable needles should be left in cancer in order to sterilize a given field. If a single viable cancer cell is left, recurrence may take place.

It is often an ordeal for the patient to tolerate removable needles in the tongue or other tissues for a number of hours, as customary with this method.

It is possible that infection, traumatism and consequent metastasis are favored by the presence of the silk or linen threads attached to removable needles.

For these and other reasons, removable tubes or needles have been largely replaced in this country by very minute tubes or ampules containing radon, which are buried by means of a fine trocar and left permanently in the tumor. These ampules may of course slough out during the healing process; often they remain permanently encysted in the tissues.

In the treatment of selected cases of carcinoma, the implantation of radon ampules made of glass has been in vogue approximately since 1917 although continued experience has shown some objectional features to their use. For example, a good deal of pain is sometimes caused by glass ampules and there may be an unnecessary amount of tissue necrosis. Hemorrhage, sometimes alarming in character, occasionally occurs during the separation of the slough.

To do away with these objections, gold ampules were ingeniously devised by Failla[1] in 1926. The primary object of gold ampules was, of course, the reduction of the transmitted beta radiation, which in the case of glass is practically 100 per cent, so as to minimize the amount of tissue reaction and necrosis.

Experiments have demonstrated that the volume of tissue necrosis following the implantation of gold ampules with a wall thickness of 0.3 mm., and a content of 2 mc., is reduced to approximately one-fifth of that caused when glass ampules containing 1 mc. are used.[2]

Experience has shown, however, that in some cases pain, persisting almost indefinitely, has been set up by the use of permanently buried gold ampules, particularly in cancer of the tongue. This feature is an almost insuperable objection to the use of gold.

Casting about for other materials, we were led to devise ampules made of capillary lead tubing. From surgical experience with ordinary "lead bullets," we believed that lead would be well tolerated by the tissues. Recently, on account of the difficulty of obtaining capillary lead tubing with a constant bore and wall thickness, we have used a lead-antimony tubing, the latter metal in the proportion of 5 per cent. Being slightly harder than pure lead, lead-antimony tubing is more easily manufactured and handled.

The internal diameter of the lead antimony tubing is 0.15 mm., the wall thickness being 0.3 mm. Each ampule is from 2 to 3 mm. long and contains from 0.5 to 1 mc. of radon, the strength varying somewhat in different cases.

We have now a small group of cases in which recovery has taken place and the

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ampules have become encysted in the tissues without giving rise to persistent pain or other undesirable symptoms.

Based on data obtained by Quimby,[3] who carried out some experiments with gold, a comparison of radiation absorbed by gold and lead respectively may be made.

Gold ampules with a wall thickness of 0.2 mm. will absorb slightly more than 99 per cent, while lead ampules with the same wall thickness will absorb 97.4 per cent of the primary beta radiation.

In all probability, 5 per cent lead-antimony ampules do not differ materially from pure lead in the amount of beta rays which they absorb. We believe the slightly greater portion of beta rays transmitted by lead or lead-antimony is not undesirable, as the hard beta rays mixed with gamma rays are approximately eight times as lethal to the cancer cell as gamma rays alone.[4]

The implantation method should be limited to carefully selected cases. In our hands the implantation of ampules in carcinoma is practically always preceded by the application of approximately 1000 mc. to the surface of the tumor.

We believe the development of lead-antimony ampules is a distinct advance in the therapy of inoperable cancer, especially when it involves the tongue, buccal mucous membrane, rectum, etc.

In the use of gold or lead-antimony ampules, a word of caution may be given. It may not be generally known that metal ampules of this type are not sealed by annealing as in the case of glass but by a special forceps which cuts and seals the ends of each ampule by mechanical pressure. In effect, a cold weld of the gold or lead-antimony is formed. Sometimes, in spite of the greatest care and skill, the weld is not perfect and a slow or fast leak develops.

Unless ampules of this type are carefully tested individually with the electroscope several times in the twenty-four hours prior to their use, there is no certainty that they contain the specified amount of radon or, indeed, any radon at all.

It is possible that failures to achieve certain results in cancer may be traced to leaks, which may easily escape detection when facilities for measuring are not at hand.

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LIMITATIONS OF THE HISTOLOGICAL GRADING OF TUMORS*

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CONTRARY to what one might suppose from a survey of recent tumor literature, the histologic grading of tumor malignancy is nothing new, nor did it originate in American pathology. As a matter of fact, tumor grading is almost as old as modern cellular pathology, for Virchow himself recognized grades of malignancy and actually employed the expression "Skala der Bösartigkeit" or "Scale of Malignancy." Tumor grades were recognized by von Rindfleisch, Borst, Schottländer, Bard, Fränkl, and others. In fact every pathologist who has dealt much in the tumor field has mentally or by elaborate description divided tumors into various grades of malignancy. Nevertheless the grading of tumors has become greatly popularized of late, largely by the substitution of figures for complicated descriptions which meant much to the pathologist and little to the clinician, and by many statistical studies which revealed the importance of tumor grades for *group* prognosis.

It is well to emphasize the expression "group prognosis." In most varieties of malignant tumors the pathologist can, from the sections alone, divide the tumors into rough subdivisions of grades I, II, and III, or perhaps more, depending somewhat on his self-assurance, and find a fair correlation between ascending tumor grade and ascending malignancy, as judged by duration of symptoms prior to therapeutic interference,[1] therapeutic success, duration of life, and extent of metastases. But what applies to a group of patients may not concern at all the individual patient and the problem of the pathologist is to endeavor to make, by using all means at his disposal, some worthwhile prognosis for the case in question.

In the individual patient, the extent of disease and the accessibility of the lesion outweigh all other considerations and the pathologist who, through clinical consultation, is able to familiarize himself with these factors as well as with the histology of the tumor in question should be able to make a far more accurate prognosis than can either the clinician or the pathologist alone. For example, with metastases to the high axilla in breast cancer or to the cervical nodes in intraoral cancer it seems to make little difference to the patient what the histologic grade is in the primary tumor, but it might make considerable difference in two tumors of the same size approximately and the same location, assuming one were a grade I and the other a grade III, and assuming likewise that in neither were the nodes clinically involved. In the former grade it might be quite justifiable to attack the local tumor aggressively and leave alone the node area, whereas in the latter the presumption is so strong that the node area is involved, though not clinically evident, that an aggressive attack on the drainage area is usually indicated.

Next to extent of disease and accessibility of lesion the fundamental tumor type is of great importance for there are groups of tumors which are almost invariably fatal no matter when they are first discovered or how accessible they are, for example the lymphosarcomas and most of the melanomas. In the latter group location seems to be of considerable importance, since the long survivals are as a rule the ocular and the subungual types although there is nothing in the histology or grading of these varieties which would make one suspect them to be of a more favorable prognosis as regards

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length of life. Fundamental tumor type is of great importance in another neoplastic disease, neurogenic sarcoma; these tumors are usually diagnosed as fibrosarcoma by the pathologist. They comprise most of the soft part sarcomas. Yet they are not fibrosarcomas in the ordinary sense but are really nerve tumors, Schwannomas, derived from the sheath of Schwann. They are a localized manifestation of von Recklinghausen's disease and although they may not look very malignant they exhibit an almost uniform tendency to recurrences, the latter not being recurrences in the true sense but new tumors developing in nerves of the same territory. It is often considered a relatively benign disease yet actually constitutes one of the worst diseases one has to deal with. Assuming that the local tumor may not recur there may be a tendency toward the development of new tumors all the way up the nerve trunk from its termination to the spinal cord. The microscope does not tell us this, but a knowledge of the fundamental nature of the tumor and its clinical course does. Examples of this sort might be multiplied almost indefinitely.

Location of disease is important since the prognosis assigned to a similar histologic grade varies greatly with the site of the tumor. For example an adenoma malignum of the rectum may closely resemble an adenoma malignum of the stomach yet it is quite different in prognosis. When adenoma malignum of the rectum penetrates the muscle coat it often spreads slowly out into the pelvic fat, whereas adenoma malignum of the stomach once outside of the organ finds a diffuse peritoneal surface to implant itself upon. In estimating prognosis then the pathologist should be able to say "This is a low grade adenoma malignum of the rectum. The tumor has slightly invaded the fat just beyond the serosa but infiltration is limited; the prognosis is fair." Under the same circumstances he would be forced to say "This is a low grade adenoma malignum of the stomach. It has reached the peritoneal surface. The probability is that tumor cells are already widely implanted. The prognosis is very bad." Going to another location, the intraoral cavity, two histologically identical sections are presented for opinion. One is from a tumor of the lateral border of the tongue anterior, the other from the pyriform sinus. In neither are nodes involved by clinical examination. The prognosis of the first is fair assuming the tumor to be a grade II. In the latter location it is bad. The location is inaccessible; infection is difficult to control; hemorrhage cannot be successfully cared for by ligation in the majority of instances and inhalation pneumonia is common. Yet the tumors may be of the same appearance microscopically and of the same size and extent clinically. The influence of radiosensitivity on prognosis cannot be adequately considered at this time.

Prognosis is greatly influenced by the condition under which the tumor arises. Again reference may be made to the rectal group. A fair number of the malignant adenomas of the rectum originate as rectal polyps. Rectal polyposis is often part of a generalized polyposis of the large bowel. Whereas the prognosis of a solitary rectal adenoma malignum might be rather good depending on its local status, the outcome of the disease might be entirely different since several polyps in a multiple polyposis might become malignant either simultaneously or successively and the grade of malignancy for one might vary from the next. This applies very much to a certain group of tumors falling in the genitourinary field, namely the papillomas of the bladder. The registry of bladder tumors grades the bladder papilloma as a benign lesion and quite correctly so. However, some bladders contain numerous papillomas, or show a diffuse papillomatosis which greatly alters the prognosis of the disease. Certain bladders show a tendency to recurring polyps in different locations over a long period. The microscope tells one that a papilloma is benign but does not tell one

that there is a diffuse papillomatosis or that there is a tendency for multiple papillomas developing successively over a period of time and therefore eliminates the most important method of estimating outcome of the disease. Neither does it tell one that the papilloma has blocked the ureteral orifices, is infected, and that ascending urinary infection is present. In fact the slide leaves out all the important factors necessary for complete understanding of the case.

The same microscopic criteria cannot be used for grading histologically similar tumors in different locations, as previous examples have shown us. An infiltrating squamous carcinoma of the lip with fairly well developed pearls may be grade II, while in the bladder it is grade III, since the low grades in the bladder apply to the papillary growths, and not to the infiltrating squamous varieties. The latter are usually the flat, non-papillary, infiltrating ulcers. This brings us to another important factor in tumor grading, namely that of anatomical type. We have been told that tumor grading should be based on the fundamental concept of cell anaplasia. Nothing is more erroneus, for various tumors whose cells exhibit marked anaplasia, are of such anatomical types that they belong in low grade varieties. If one grades on the basis of anaplasia, then one must grade according to the degree of anaplasia within the certain anatomical tumor type. The breast group is an excellent example. We have within the breast certain tumors which develop within cysts or dilated ducts. They grow often rapidly to large size and ulcerate the skin. They are often extremely cellular and anaplastic and yet they are slow to involve lymph nodes. Although anaplastic they should constitute the grade I of breast cancer. Their comparative prognosis with the infiltrating duct carcinoma of the breast is similar to the comparative prognosis of cellular papillary bladder carcinoma to the infiltrating squamous type.

There are certain local conditions within an individual tumor which alter prognosis and which section will fail to bring out. A rectal tumor of low grade may accidentally invade a vein. The case reported by Dr. McNattin was not a highly malignant tumor, but a renal tubule carcinoma not very cellular and very calcific. Yet it had accidentally invaded the renal vein and metastasized and its metastatic cells under different physiological, nutritional circumstances had become extremely anaplastic and malignant. The metastatic cells had survived and multiplied in very unusual locations, for example the cardiac muscle and the tongue.

Lastly, physiological status and unexplained local inflammatory conditions may alter prognosis. Breast carcinoma developing during lactation or pregnancy has an almost uniformly rapid course and fatal prognosis. The same is true of breast cancer developing in an inflammatory setting: the acute inflammatory carcinosis of the breast. Delbet saw one such patient die within six weeks of the onset of disease. Inflammatory carcinomas and carcinomas of lactation or pregnancy may not look worse under the microscope than do other carcinomas, and yet they are distinct clinical entities.

CONCLUSION

1. Any prognosis based upon the purely histological grading of tumors should apply to a group rather than to an individual.
2. If prognosis is to be ascertained with any degree of accuracy for an individual it must be based upon
   (a) Gross tumor anatomy and fundamental tumor type
   (b) Histology
   (c) Location, extent and accessibility; solitary or multiple setting; nature of tumor bed
   (d) General and special physiological status of the individual
   (e) Radiosensitivity of the tumor.
3. In the absence of all the ascertainable facts about an individual patient, no reasonably accurate prognosis is possible.
4. Individual prognosis should be based on clinical-pathological consultation whenever practical, rather than on the clinical examination or the microscope alone.

THE PATHOLOGY AND TREATMENT OF MALIGNANT NEOPLASMS OF THE TESTICLE*

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MALIGNANT testicular neoplasms are rare. Their incidence is 50 cases in 300,000 admissions to the Mayo Clinic, Rochester, Minn., or 1 case in 6000, in a material for the most part ambulatory and chronic (Tanner).

The pathological museum of the Sydenham Hospital, New York, has 8 specimens. This represents the material of 9511 admissions to the hospital in the thirty months up to June 24, 1929, and is about five times its quota.

These tumors are so rare that few surgeons have an experience of more than a few patients, upon whom they have personally operated. Most of the studies in the literature are those of workers who have had the benefit of the records of large institutions.

Among these are the studies of:

	Cases	
Chevassu	112	
Tanner	101	
Cairns	93	
Nicholson	65	
Howard	65	
Dew	39	
Hinman	30	(Johns Hopkins Hospital)
Geist and Thalhimer	26	
Hinman et al	22	(University of California cases)
Ewing	19	
Schultz and Eisendrath	14	
O'Crowley and Martland	13	
Dean	6	

PATHOLOGY

Out of the maze of faulty observation and misinterpretation, Chevassu in 1906 in a study of 128 tumors, not all malignant, mostly from the Paris clinics, some of which he observed clinically, others which he studied merely from museum specimens, gave a classification which is considered by some to have stood the test.

CHEVASSU'S CLASSIFICATION OF 128 TESTICULAR TUMORS

		Case
Epitheliome seminal	59	1– 59
Tumeur des cellules interstitielles	1	60
Adenome testiculare	3	61 - 63
Fibrome	1	64
Sarcome	1	65
Embryome	62	66–127
Tumeur secondaire	1	128
Of the 62 Embryomes:		
Teratomes	7	66– 72
Tumeurs mixtes non degenerees micr.	5	73– 77
Tumeurs mixtes degenerees	50	78–127
Of 50 Tumeurs mixtes degenerees:		
Degenerescence sarcomateuse	5	78– 82
Degen.—Type epithelioma infiltre (adeno carcinoma)	17	83– 99
Degen.—Type epithelioma papillaire (papillary carcinoma)	15	100–114
Degen.—Type placentaire (chorio-epithelioma)	13	115–127

Briefly, his views were that the majority of malignant testicular tumors were either *degenerated embryomata* (the so-called mixed or teratoid tumors of other writers), or *seminomata* (a solid tumor derived in his opinion from the epithelium of the seminiferous tubule). He held that the latter are not teratoid and that he could find no relation between the two groups, which form 121 of the 128 testicular tumors embraced in his study. His classification is really a list in which these types predominate numerically.

In 1911, Ewing followed with a study, and later in his work on Neoplastic Diseases gave the following classification:

Teratomata testis are divided into:

I. Adult embryomata or teratomata

II. Embryoid, teratoid or mixed tumors

III. Embryonal malignant tumors

* From the Pathological Laboratory of Sydenham Hospital, Dr. A. A. Eisenberg, Director.
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This is based on an idea originated by him and concurred in by others, particularly Hinman, that the epithelioma seminal

Fig. 1. Dew's Case 31, showing development of carcinoma in seminiferous tubules.

or seminoma of Chevassu, is not a tumor separate and distinct from the malignant embryoma, but that it is an embryoma or teratoid tumor, in which there is a one-sided cellular development, resulting in a homologous-celled tumor with lymphoid stroma. His view is that this large (spheroidal) type of epithelial cell overgrew the other cells in the development of the embryoma in an organ, the epithelial structures of which contain totipotent cells in large numbers.

This theory is attractive but thought by some to be unproved, and has caused the observers to divide into two groups.

Ewing says in discussing Case 9 of his series of 19 specimens, which case was a typical "seminoma" with marked necrosis, in which no trace of columnar or flat epithelium, cartilage or muscle could be found: "The conclusion that the tumor is a one-sided development of a teratoma is based on the fact that its highly peculiar structure is exactly duplicated in other tumors of this series in which tridermal elements were demonstrated." This is not an entirely convincing argument, as there is no reason why embryomata cannot develop areas identical with "seminomata" from seminal cells, as this type of origin is not disproved and is the point under discussion. Also half of the malignant testicular tumors are histologically pure "seminomata" in which other elements are practically never found.

A good argument in favor of Ewing's theory would be the finding of elements from two or more germ layers in specimens that were apparently "seminomata," by serial sections of such tumors. Dew tried to substantiate this and failed. Hinman succeeded in one of his seminomata. He states that Ewing was able in several instances to demonstrate seminomatous tissue in teratomata (embryomata), and tissue of other germ layers in seminomata.

While the cell of the seminoma has a strong resemblance to the cell of the normal seminiferous tubule, the strongest morphological evidence would be the finding in an early tumor of areas in which the normal seminiferous tubule shows the development of tumor cells. Dew shows a specimen (Case 31) with a tumor starting in the lower pole of the testicle, in which the section seems to show definitely that the spheroidal cell carcinoma (seminoma) starts in some of the adult seminiferous tubules.

Schultz and Eisendrath agree with Chevassu, claiming that the seminomata are derived from seminal epithelium. They offer the term spermatocytomata to replace seminoma. Unfortunately they use the term embryonal carcinoma for embryoma, which further complicates the nomenclature, as Ewing introduced this term in 1911 to designate the tumors called seminoma by Chevassu and to indicate that they were carcinomata of an embryonal type and not imitative of any glandular structure.

A better term than any is that used by Dew, spheroidal cell carcinoma, as it does not attempt to indicate the origin of the tumor, which point is under discussion.

The classification of Schultz and Eisendrath however has excellent features.

Classification of Schultz and Eisendrath —1921

I. Homologous Tumors
  A. Benign seminiferous tubules
    Epithelial (adenoma of Chevassu and Pick)
  B. Malignant
    Spermatocytoma (the seminoma of Chevassu; the embryonal carcinoma of Ewing)
II. Heterologous Tumors
  A. Benign
    Adult teratoid tumors or cystic dermoids
  B. Malignant
    1. Embryonal carcinoma (embryone of Chevassu)
      Heterologous tissue may be present or may have been overgrown. The typical tissue may be:
      a. Trophoblastic (chorioepithelioma)
      b. Hypoblastic (the usual adenomatous tumor)
      c. Epiblastic (solid alveoli of basal cell type or tumors of neurocytoma type)
    2. Sarcomatous mixed tumors very rare as a pure tumor; probably the few authentic cases of sarcoma reported as heterologous tumors represent one-sided development of teratomata.

Hinman et al. prefer to modify Schultz and Eisendrath's classification. They accept their idea of calling embryomata, embryonal carcinoma, but place the seminoma under this heading, as being of mesoblastic origin, which they themselves realize is unproved. Their classification is:

I. Homologous Tumors
  A. Benign
    1. Epithelial
      a. Adenoma of the seminal tubules (the tumors of Chevassu and Pick are accepted by Ewing)
    2. Mesoblastic
      a. Interstitial cell tumors (probably not true tumors, but merely hyperplasia-Ewing)
  B. Malignant (do not occur)
II. Heterologous (teratomata or mixed tumors)
  A. Benign
    1. Adult teratoid tumors or cystic dermoids (exceedingly rare)
  B. Malignant (embraces practically all tumors of the testicle)
    1. Embryonal carcinoma (heterologous tissues may be present or may have been overgrown)
      a. Trophoblastic (chorioepithelioma)—rare
      b. Hypoblastic (the usual adenomatous tumor)
      c. Epiblastic (solid alveoli of basal cell type or tumors of neurocytoma type)
      d. Mesoblastic (?) (so-called seminoma—they constitute about one-half of the malignant tumors occurring in the testicle)
    2. Sarcomatous mixed tumor (true sarcoma occurring in teratoma is very rare; probably the few authentic cases of sarcoma reported as homologous tumors represent one-sided developments of teratomata.

For a working classification, the best and simplest is that of Tanner:

A. Malignant
  1. Carcinomatous large cell large nucleus type undoubtedly closely related to the mixed type
  2. Mixed type
    a. Tumors containing cartilage, cysts, glands, etc.

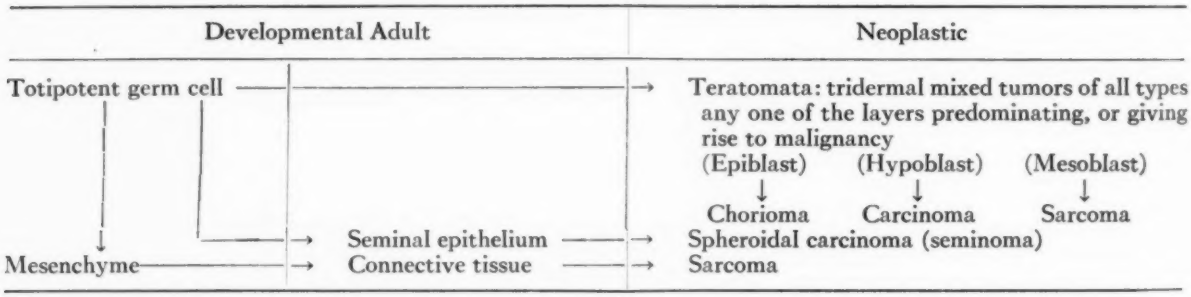
b. Ordinary glandular structure tumors
c. Chorioepithelioma

B. Benign
1. Dermoid
2. Epithelial
a. Adenoma of the seminal tubules as described by Chevassu and Pick
3. Mesoblastic
a. Interstitial cell tumors
b. Fibroma
c. Lipoma, myxoma, etc.

In his classification, carcinoma is the seminoma of Chevassu, or the spheroidal cell carcinoma of Dew and other English writers. We shall in this article use the latter term from now on.

Tanner's classification has under mixed type a subheading, a, tumors containing cartilage, glands, etc. This mixed tumor is the malignant embryoma; we shall use this term from now on.

Such a classification is not only practical, but it takes sides with Dew's conception of the probable histogenesis of these tumors from the totipotent cell:



This idea sides with Chevassu, which seems more probable from a morphological standpoint, until thoroughly refuted by other methods of investigation.

The morbid anatomy of malignant neoplasms of the testicle will be described under the Procedure of the Radical Operation. It was arranged in this manner because from a practical standpoint it is necessary for the surgeon to have a good knowledge of the gross appearances of the cut section of these tumors in order to use this in conjunction with other data in deciding whether or not to proceed upon the radical operation after preliminary orchidectomy has been done.

PATHOLOGICAL HISTOLOGY

From a histological standpoint the two types of malignant tumors, which embrace nearly all of the testicular tumors are firstly, the spheroidal cell carcinomata of the homologous tumors, and secondly, the malignant embryomata of the heterologous tumors.

This attitude seems more advantageous at present, until further studies and discoveries have rendered more certain the theory of the unity of their pathogenesis.

The carcinomata are composed of one type of cell, a large cell, usually spheroidal or ovoid in shape, pale and transparent. At times there is a cobweb appearance due to the fine tendrils which extend from the periphery of the cell body to other cells. The nucleus is compact and stains deeply. The carcinoma cells are supported by a delicate framework of fibrous tendrils, which hold in their meshes very tiny deeply staining cells, that look like small lymphoid cells. This framework with its lymphoid stroma varies in amount in different specimens, although it is never abundant enough to give the tumor a fibroid texture. There is no true alveolar formation, but there is a tendency in some specimens toward this as described by Geist and Thalhimer and used by them in attempting to differentiate various histologic types. Carcinomata are for practical purposes histologically homologous, although some observers claim to have found by serial sections tissue of other germ layers.

Carcinoma resembles the granulomatous type of testicular syphilis very much, especially when the lymphoid stroma is not in great evidence. This makes the differentiation very difficult, as grossly such tumors have a cut surface that looks similar, and unless the frozen section is very excellent, the microscopist is at a great disadvantage.

The embryomata are histologically heterologous or mixed tumors. Histologically all three of the germ layers may be represented although most commonly mesoblast and hypoblast are found. They usually present hypoblastic glands lined with columnar epithelium, some of which may contain goblet cells, such as are found in the gastrointestinal tract. Other cysts are found lined with cuboidal and columnar epithelium. There are myxomatous areas, although most of the supporting framework is of firmer fibrous tissue. In some are to be found areas of cartilage, neuroepithelium and cysts filled with colloid material taking the eosin stain and somewhat resembling thyroid alveoli.

Up to this point in the description, the embryoma does not appear histologically very malignant, although cases have been reported in which there have been metastases from such tumors containing even cartilage. Such a case was reported by Paget. However, as a rule, these tumors show a tendency at some time or other to degenerate in some of their areas into papillary or into adenocarcinoma. These are the ones in which metastasis is a danger. These degenerated areas occur only in certain parts of the mixed tumor, the tumor requiring therefore numerous blocks from various parts in order that this be not overlooked. Other portions not far removed show only the mixed tumor just described.

We have seen both of these types of degeneration in our series. We have not encountered any areas in our mixed tumors, that resemble the spheroidal cell carcinomata, although the specimens have not been serially sectioned.

A word must be said about the pathological anatomy and histology of the syphilitic testicular tumor. Some of these

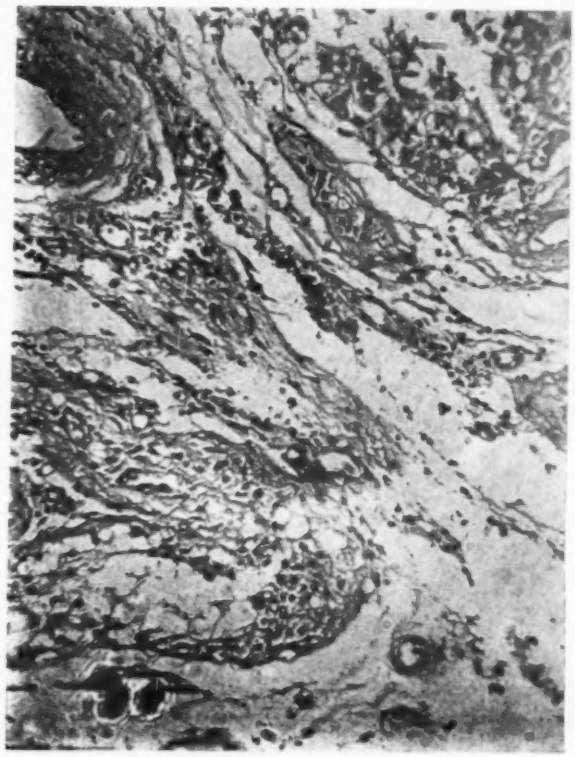


Fig. 2. Similar development in 1 of our cases, Path. No. 2343. Note similarity of carcinoma cells to cells of normal seminiferous tubules in neighborhood of tumor cells.

show nodules with geographical or circinate margins (gummata). Others are merely homogeneous tissue very like the carcinomata. Histologically two types are found. In the former there is a great deal of fibrosis enclosing only nests of round cells. In the latter, the homogeneous or granulomatous type, the tissue resembles granulation tissue and has many capillaries supporting a tissue composed almost entirely of moderately sized mononuclear cells; it is this type that resembles histologically the spheroidal cell carcinoma, when this tumor has little or no lymphoid stroma. We present two specimens which represent one of each type.

Our photomicrographs will show representative areas of each type of malignant tumor, as well as some of the representative types of tissue found in embryomata,

including the varieties of carcinomatous degeneration. Microscopic areas of syphilitic testicles will be shown for comparison.

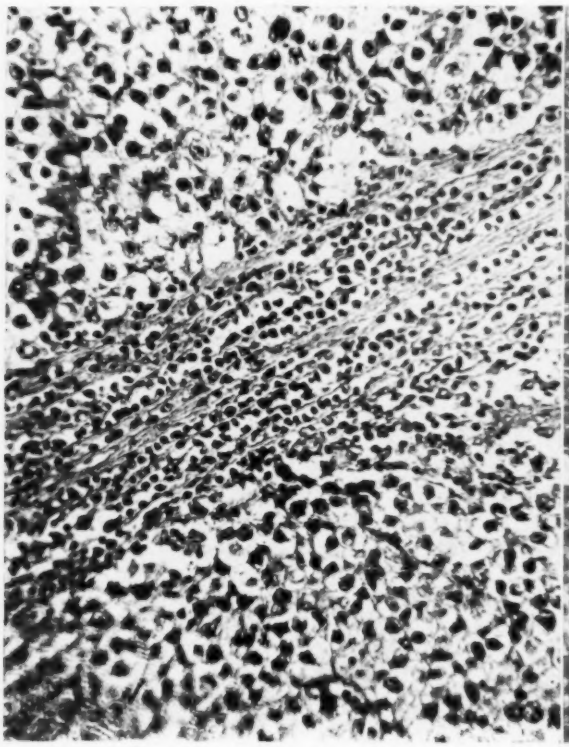


Fig. 3. Pathological No. 1884. Spheroidal cell carcinoma with typical lymphoid stroma.

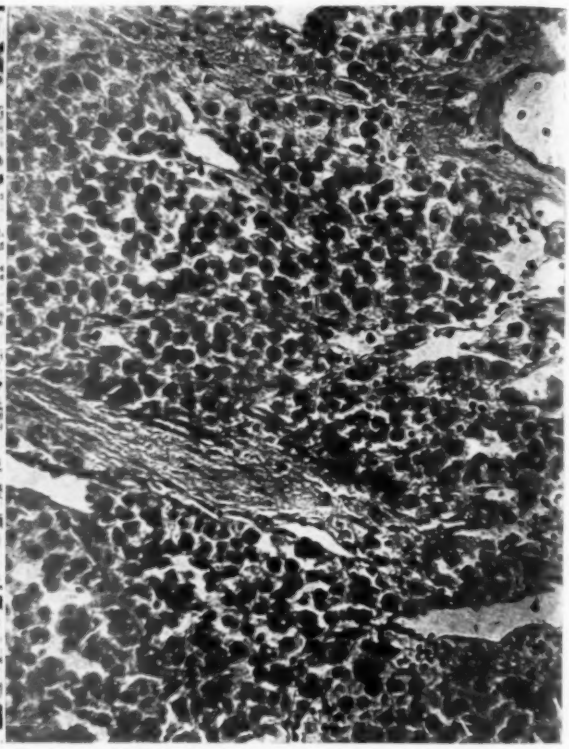


Fig. 4. Pathological No. 2904. Spheroidal cell carcinoma showing paucity of lymphoid stroma. This type although more cellular resembles granulomatous type of syphilis.

CASE REPORTS

Abstracts of the histories of cases in the Sydenham Hospital series are here given.

They consist of 5 cases of spheroidal cell carcinoma; 3 cases of malignant embryoma; and also the histories of 2 cases of syphilitic testicular tumor are given.

It will be noted that there is a slight discrepancy in some cases in the nomenclature of Pathological Diagnosis found on the chart, as compared with that of the Revised Diagnosis, which latter refers to the study of the author.

ABSTRACTS OF CASE HISTORIES FROM SYDENHAM HOSPITAL RECORDS

Case I. History No. 4941; Pathological Laboratory No. 1315.

P. G. Aged thirty; Admitted June 5, 1928; discharged June 10, 1928.

Painful mass of six weeks' duration in right side of scrotum.

Physical Examination: Right side of scrotum contains a hard painful mass involving the epididymis; skin of scrotum reddened. No abdominal masses felt.

Provisional Diagnosis: tuberculous epididymitis.

Operation: June 5, 1928, orchidectomy.

Pathological Diagnosis: teratomatous adenocarcinoma.

Gross Pathology: The tissue is solid in one portion; in another portion it is filled with cystic areas.

Microscopical Pathology: The tissue is distinctly papillary adenocarcinoma; there are also acini lined with a single layer of columnar epithelium of endodermal origin.

Revised Diagnosis: Embryoma (with papillary adenocarcinomatous degeneration).

After Course: July 18, 1929. Admitted to Bellevue Hospital for pulmonary tuberculosis.

Case II. History No. 9511; Pathological Laboratory No. 2904.

Anthony B. Aged thirty-two; Admitted June 24, 1929; discharged July 6, 1929.

Swelling of the right testicle for one year; occurred after trauma; gradual increase.

Physical Examination: Mass in right side of scrotum, size of a man's fist.

Provisional Diagnosis: Tumor of the right testicle.

Operation: June 26, 1929, orchidectomy.

Pathological Diagnosis: seminoma (embryonal carcinoma).

Gross Pathology: Shaped like a testicle and about five times as large; on section it shows grossly some small cystic area but the tissue is for the most part solid, greyish, divided by trabeculae into lobules; tunica vaginalis is not involved; epididymis shows caseous (?) cavities.

Microscopical Pathology: Typical seminoma with marked fibrous trabeculae; not much lymphoid stroma. Veins of the cord are not involved.

Revised Diagnosis: Seminoma (same as preceding).

Case III. History No. 6825; Pathological Laboratory No. 1884.

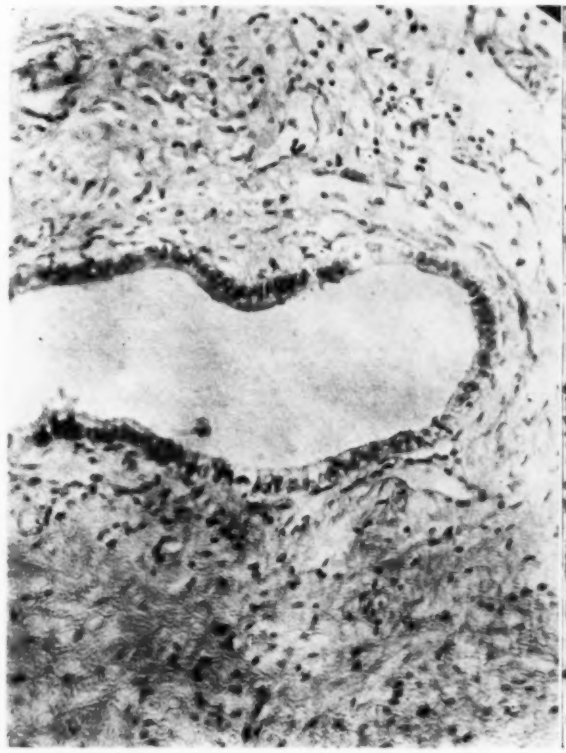


Fig. 5. Pathological No. 1315-2. Malignant embryoma showing a gland of hypoblastic type lined with columnar epithelium, lying in myxomatous matrix.

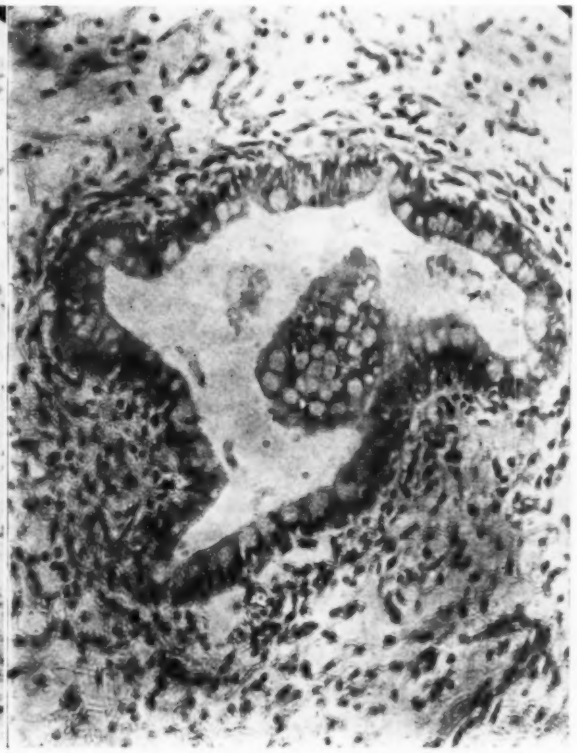


Fig. 6. Pathological No. 2023. Malignant embryoma showing intestinal type of gland with goblet cells.

Aron P. Aged fifty-seven; Admitted Nov. 15, 1928; discharged Dec. 2, 1928.

Right hernia fifteen years ago; left-sided cryptorchism.

Four months ago the left cryptorchid became swollen and painful.

Physical Examination: Mass present in left inguinal region, size of an egg; movable, and not very tender.

Provisional Diagnosis: Not noted.

Operation: Nov. 16, 1928. Left-sided orchidectomy.

Pathological Diagnosis: Embryonic sarcoma of the testicle.

Gross Pathology: Mass shape of and twice the size of a testicle; tunica not involved; solid on section, smooth, no cysts, some necrotic spots, some lobules.

Microscopical Pathology: Seminoma, with typical lymphoid stroma.

Revised Diagnosis: Seminoma.

Case IV. History No. 7944; Pathological Laboratory No. 2343.

Herman G. Aged sixty-two; Admitted Feb. 25, 1929; discharged March 10, 1929.

Trauma to right thigh three months ago; several days later right testicle swelled; a hydrocele was tapped several times.

Physical Examination: Right side of scrotum contains a mass $2\frac{1}{2} \times 2 \times 1$ in. Firm, not tender; skin movable; both testis and epi-

Fig. 7. Pathological No. 166-1. Malignant embryoma. An area showing simple gland adjacent to area of cartilage.

Fig. 8. Pathological No. 166-4. Malignant embryoma. An area showing goiter-like alveoli.

Physical Examination: Right testicle size of a tangerine, tense fluctuant; transmits light; abdomen negative.

Provisional Diagnosis: Internal hydrocele.

Operation: Feb. 27, 1929. Right orchidectomy.

Pathological Diagnosis: Reticulum cell sarcoma.

Gross Pathology: On section the tumor looks like marble; the epididymis shows caseous (?) areas.

Microscopical Pathology: It is mostly fibrous tissue enclosing areas of cobweb cells with large areas of early degeneration; no lymphoid stroma seen.

Revised Diagnosis: Seminoma.

Case v. History No. 2637; Pathological Laboratory No. 589.

Ralph S. Aged twenty-nine; admitted Nov. 4, 1927; discharged Nov. 16, 1927. Right testicle began to enlarge two years ago; Wassermann test negative.

didymis seem involved. Cord normal.

Operation: Nov. 4, 1927. Castration, local anesthesia.

Pathological Diagnosis: Large round celled sarcoma.

Gross Pathology: Tunica not involved; on section it is composed of small cavities filled with cobweb like tissue; the walls of the cavities are supported by fibrous trabeculae. In one area there seems to be normal or compressed testicle. Grossly the tumor resembles embryoma on account of the cavities.

Microscopical Pathology: The tumor is composed of embryonal carcinomatous cells spheroidal in shape with lymphoid stroma.

Revised Diagnosis: Seminoma.

Case vi. History No. 729; Pathological Laboratory No. 166.

Harry W., admitted April 21, 1927; discharged May, 6, 1927. Swelling of the right testicle four months ago; aspirated but no fluid obtained.

Operation: April 22, 1927. Right orchidectomy.

Pathological Diagnosis: Malignant teratoma with adenocarcinoma.

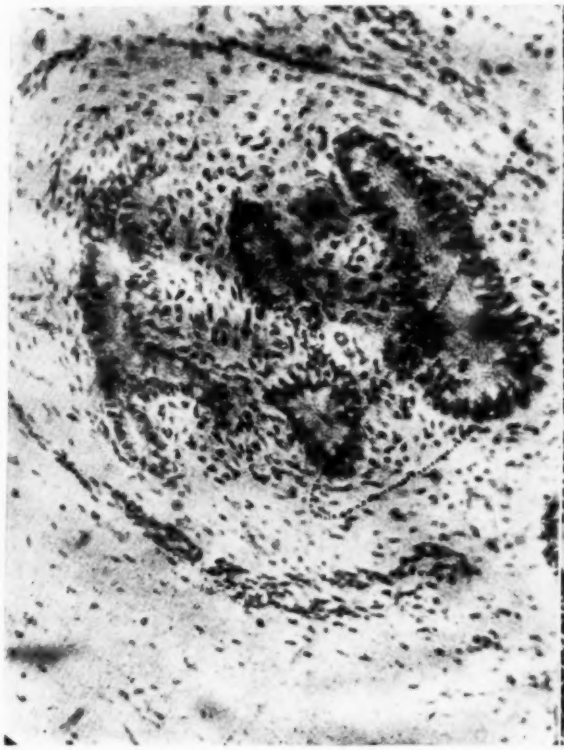


Fig. 9. Pathological No. 166-2. Malignant embryoma. An area showing neuroepithelial rosettes.

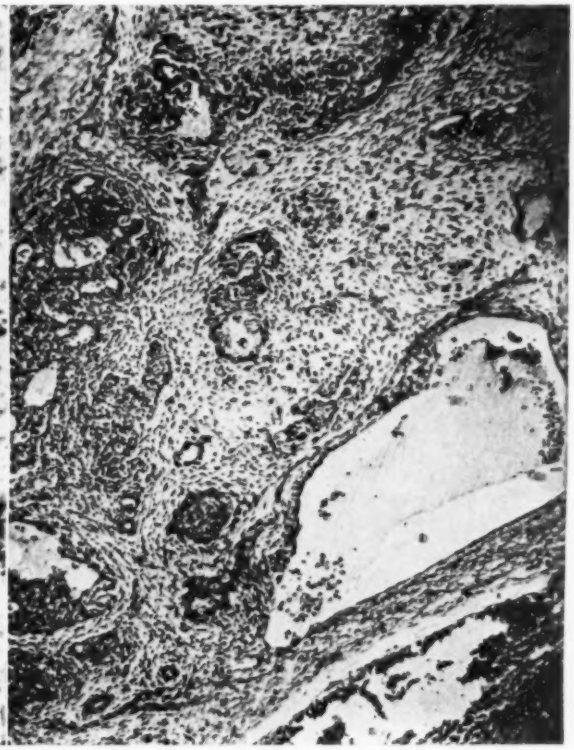


Fig. 10. Pathological No. 166-3. Malignant embryoma. An area showing adenocarcinomatous degeneration.

Gross Pathology: Tunica not involved; on section there are many cysts; the epididymis is hemorrhagic.

Microscopical Pathology: There are cystic alveoli lined with columnar epithelium; myxoma; cartilage; "rosettes of neuroepithelium"; adenocarcinomatous areas; no seminoma is present.

Revised Diagnosis: Embryoma with adenocarcinomatous degeneration.

Case vii. History No. 7119; Pathological Laboratory No. 2023.

Alexander P. Aged thirty-one; admitted Dec. 13, 1928; discharged Dec. 21, 1928. Mass began to form in right side of scrotum three months ago; tapped twice but only blood stained fluid obtained. Is increasing in size but is not tender.

Physical Examination: In right side of scrotum is an orange sized mass, heavy, hard, firm, smooth; skin movable; does not transmit light.

Operation: Dec. 14, 1928, orchidectomy.

Pathological Diagnosis: Malignant teratoma.

Gross Pathology: Solid tumor of rather glairy tissue; shaped like a testicle; some cystic areas; some meaty and some fatty looking areas.

Microscopical Pathology: Tissue resembling myxoma or myxosarcoma with glandular elements lined with columnar epithelium, probably of hypoblastic origin.

Revised Diagnosis: Embryoma.

Course: In Montefiore Home Jan. 9, 1929.

Case viii. History No. 8475; Pathological Laboratory No. 2489.

Jas. E. Age thirty-six; admission April 8, 1929; discharged April 15, 1929. Noticed that left testicle was enlarging one and one-half years ago.

Physical Examination: Left testicle size of a fist, hard and painful on pressure.

Operation: April 8, 1929, orchidectomy.

Pathological Diagnosis: Seminoma.

Gross Pathology: Tumor the shape of and about three times the size of a testicle. On section the tissue is pale and homogeneous and contains little nodules. No cysts; testis not identified; epididymis not involved.

Pathological Histology: Pale spheroidal cells with lymphoid stroma; much mitosis; much degeneration. The epididymis shows areas of tumor growth; there are metastatic cells in the veins of the cord.

Revised Diagnosis: Seminoma (same as preceding).

Fig. 11. Pathological No. 1315-1. Malignant embryoma. An area showing papillary carcinomatous degeneration.

Case IX. History No. 9863; Pathological Laboratory No. 3007.

Samuel B. Aged fifty-eight; admitted July 21, 1929; discharged July 29, 1929. Hydrocele of left side for three or four months occurring after trauma; gradual painless enlargement of the left testicle; repeated tapping and return of fluid.

Physical Examination: In left scrotum is a mass, not tender; transilluminates.

Preliminary Diagnosis: Hydrocele.

Operation: July 22, 1929. Winkelmann operation on left testicle followed by castration.

Pathological Diagnosis: Gumma of testis.

Gross Pathology: Tumor in the center of testis; has a geographical margin; hard and white.

Pathological Histology: Very little fibrosis; in general the testis is replaced by granulomatous tissue with thin walled capillaries and giant cells. No necrosis is present.

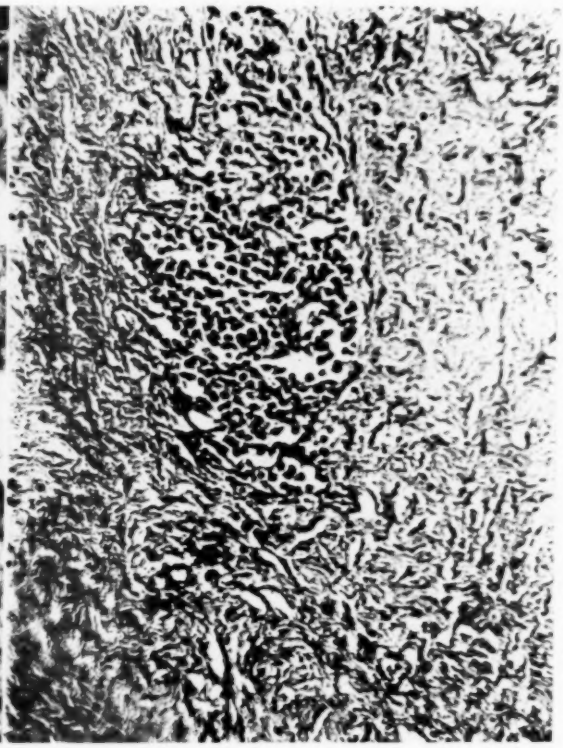


Fig. 12. Pathological No. 2029-2. Syphilitic testicle. An area from a gumma, showing fibrous tissue and a nest of round cells.

Revised Diagnosis: Gumma (same as preceding).

Case X. History No. 7130; Pathological Laboratory No. 2029.

Jacob L. Aged fifty-five; admitted Dec. 14, 1928; discharged Dec. 21, 1928. Inflammation of left kidney for tree years. Left testicle has been swollen for four weeks.

Physical Examination: Left kidney palpable; left testicle size of a goose-egg, hard, smooth, not attached to skin.

Preliminary Diagnosis: Luetic orchitis (by house surgeon).

Operation: Dec. 15, 1928. Left orchidectomy.

Pathological Diagnosis: In all probability it is syphilis of the testicle.

Gross Pathology: The tissue is firm homogeneous tissue which on section shows no cysts.

Microscopical Pathology: There is very great fibrosis; the fibrous trabeculae enclose

areas of granuloma; no giant cells are seen; a necrotic portion is noted.

Revised Diagnosis: Gumma of testis.

Fig. 13. Pathological No. 2029-1. Syphilitic testicle. Another area, somewhat fibrous but more granulomatous.

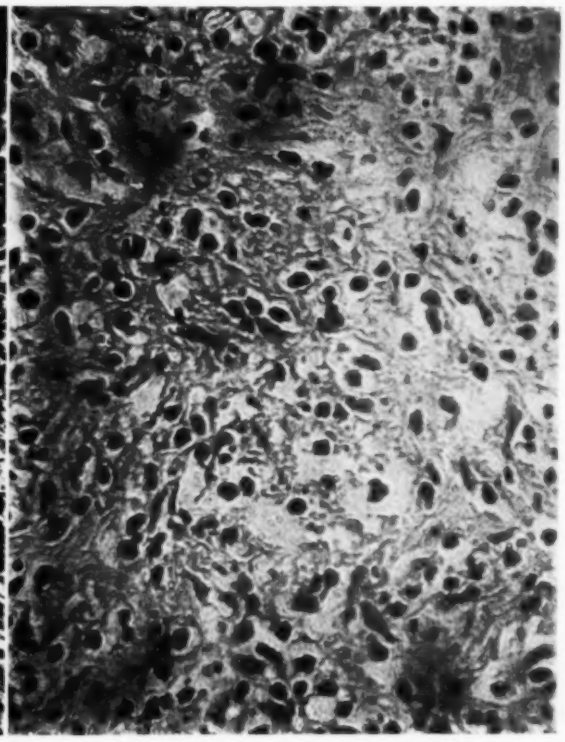


Fig. 14. Pathological No. 3007. Syphilitic testicle. Pure granuloma. This somewhat resembles spheroidal cell carcinoma (compare No. 2904, Fig. 4).

TREATMENT

Neoplasms of the testicle proper, are nearly all extremely malignant. Fortunately they are rare. Unfortunately their rarity prevents any urologist from acquiring any great amount of personal experience with them.

The operation of castration is of slight value although easy to perform. The radical operation is one of great difficulty and one requiring an extensive knowledge of the anatomy of a region seldom entered surgically. Hence the entire subject is in an unsatisfactory state, out of which radiotherapy, preoperative and postoperative, is said by its advocates to offer a ray of hope, but so far not enough unquestioned evidence has been accumulated to thoroughly systematize such claims and hopes.

ORCHIDECTOMY

This operation is the logical and natural one. It is easy to perform. It has practically no mortality. It is still the operation in vogue. Its results depend on whether the tumor cells are already disseminated, in paths which will be discussed later.

What are the results of simple orchidectomy?

Among the older writers Kober (1899) found that of 105 cases of "sarcoma" (this term was used at that time) so treated; only 9 patients were alive in three years.

Of 100 cases analyzed by Chevassu (1906) 19 patients were alive from four to ten years after operation. Of these, 16 had seminomata (spheroidal carcinomata) and 3 had malignant embryoma.

Tanner (1922) analyzed 600 cases of patients so operated. He was able to find reports of 465 traced cases. Of these only 5½ per cent were alive four or more years. Two patients died of metastases six years after operation.

Dew in 37 cases has one that he considers a cure; the patient is alive twenty-two years after operation.

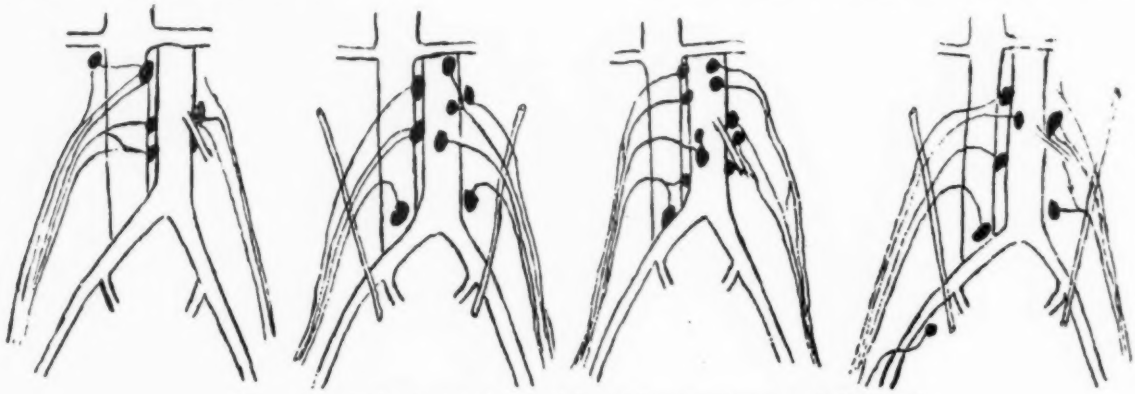


Fig. 15. Lymphatics of the testicle. (After Jamieson and Dobson.)

Hinman (1914) reports only 3 cured of 18 patients so operated on.

Dew (1925) reported 15 patients having embryomata whom he had followed up; of these all were dead of metastases except 4 recent cases, which were under twenty months, and two of these patients already had glandular metastases.

Dew followed up 6 carcinomata; 3 patients are alive, 1 two years, 1 one year and 1 twenty-two years after operation.

These results are similar to those that occurred in the period before the radical operation for carcinoma of the breast.

THE PATHS OF EXTENSION OF THE MALIGNANCY

Formerly when these tumors were considered sarcomata, it was a surprise that they should in most cases metastasize by a lymphatic route. This discrepancy was cleared up later, when it was found that sarcoma of the testicle was so rare, that it is doubtful in the minds of some authorities, whether a proved specimen exists. As soon as it was understood that the tumors were derived from epithelium, the lymphatic route of extension was understood.

There is no superficial lymphatic route from the testicle to the superficial inguinal glands, unless the skin of the scrotum is involved. This is very important as it is practically never involved, except after operation and *exploratory puncture.*

Tumors rarely fungate, except in the latest stages and by this time the deep lymph channels are affected.

Whenever the superficial inguinal nodes are involved, if there has been no needling and no operation and the skin is movable over the tumor, they are involved *in retrograde fashion*, and are presumptive evidence that the deep lymphatics are involved, even though there are no palpable abdominal masses. Such a case is inoperable.

Primarily the spheroidal cell carcinomata and the malignant embryomata involve the deep lymphatics, the latter earlier and more regularly than the former.

According to the work of Jamieson and Dobson such tumors follow the spermatic cord to the ureter, and then enter the *primary* lumbar lymph nodes. These lie in front of the aorta and the vena cava. On the right side one or more nodes lie in the groove between the aorta and the vena cava. On the left side they lie to the left of the aorta and near the root of the mesenteric artery. The chain of nodes extends from the beginning of the common iliac artery to the renal vessels.

The *secondary* glands involved are:

a. the primary glands of the opposite side,

b. glands behind and between the great vessels, above and below the level of the renal veins.

When these secondary glands are involved, especially those behind the

great vessels, the masses are of course irremovable.

The *superficial* inguinal glands are never primarily involved, unless the tumor cells involve the skin of the scrotum. This occurs primarily only in the very late stage, when the neoplasm has attached itself to the scrotal skin, and has ulcerated through, producing a fungating mass. This condition is rarely seen at present. However, recurrent masses, after orchidectomy, act in the same manner.

The skin of the scrotum may be infected with tumor cells after tapping. This is unfortunate, as hydrocele is the commonest tumor in the scrotum. For this reason, and because an occasional case of hydrocele is cured by tapping, and because it is at times difficult to differentiate soft areas in a testicular mass from fluctuation, and because the transillumination test is sometimes unsatisfactory, scrotal masses are subjected to much indiscriminate needling for diagnosis.

The danger of infection of the skin is great and implantation of tumor cells into the skin means practically a fatal outcome even if surgery is done.

The only fortunate thing about testicular neoplasms is that the infection of the deep lymphatics is usually late, especially in the spheroidal carcinomata.

Some few testicular neoplasms metastasize through the veins like hypernephromata of the kidney. These are the extremely rare *genuine sarcomata* and choriomata a case of which later was described by McCallum. An excellent case report and review of the former subject were made by Cooke.

These are direct extensions into the lumina of the veins with in addition the distant transplantation of cell nests into the lungs and other organs.

THE RADICAL OPERATION

The preceding discussion of the extension and paths of metastases naturally points toward the futility of simple orchidectomy. Only a case without previous extension to the deep chain of lymphatics will allow a cure after mere orchidectomy.

What can be done by removal of the lymphatic areas in addition to orchidectomy?

This operation is a formidable procedure. Does it give an additional percentage of cures?

Is this additional percentage of cures discounted by the increased percentage of direct surgical mortality?

HISTORY OF THE RADICAL OPERATION

The radical operation for malignant disease of the testicle bears the same relationship to simple castration that the radical operation for carcinoma mammae bore to simple breast amputation. The conception is the same and is based on the study of lymphatic areas quite far removed from the original site of the malignant disease.

In both cases the removal of these lymphatic areas prolonged the operation considerably and added to the shock. Also the dissection of fat containing lymphatic areas necessitates a dissection upon the sheath of large arteries and veins and requires surgical ability of high degree, and even with this increases mortality of the operation. It required some time for the surgical world to accept these risks but they are accepted as a matter of course in the case of surgery of the breast. The reception of the operation by surgeons has been slower in the case of the testicle.

As long ago as 1909, Bland-Sutton referred to simple orchidectomy as "the ancient operation of castration for malignant disease." While others such as Roberts in 1902 had unsuccessfully attacked retroperitoneal masses transperitoneally, it remained for Gregoire in 1905 to perform the first extraperitoneal operation. Cuneo followed in 1906 with the first successful operation. He was followed by Chevassu who developed the technique which was followed in France by Gosset, Fredet, Delbet, Michon and Panchet;

in England by Howard and Davies; in the United States by Hinman and others.

THE PROCEDURE

The spermatic cord is carefully exposed by a high inguinal incision. It is double clamped and divided by the *actual cautery*. The field is packed with alcohol soaked towels. The scrotal mass is carefully removed.

The surgeon should then slice the tumor entirely through for inspection, using a side table so as not to infect the operative field.

The gross pathological features are of great importance. They are as follows:

Tumors beyond first-size are usually *malignant embryomata*. These have a soft encephaloid consistency and are often yellow pink and reddish in spots, varicolored. They are more friable than the carcinomata. Neither embryomata nor carcinomata invade the tunica vaginalis except in the latest stages. The epididymis is usually involved and thinned out. Embryomata in nearly all cases have cyst-like cavities, ranging from pinhead to small cherry size. Some have a honeycomb appearance. The presence of these cysts is usually diagnostic, as they rarely occur in the carcinomata. (Our series has 1 case of a spheroidal carcinoma with cysts.)

The *spheroidal carcinomata* like the embryomata do not invade the tunica but are more likely to invade and replace the epididymis, which is solidly replaced *without caseous areas*, as occur in tuberculosis. There are however in some cases inspissated areas in the epididymis, which look somewhat like tuberculous epididymitis.

The cut section of the carcinoma is firmer than that of the embryoma; it has a pearly gray appearance and fleshy consistency like a "giant scallop." It looks like typical sarcomatous tissue. When small, part of the testicle may be identified. It is not as a rule as firm as the *luetic testis* and does not have in it the gummatous nodules with "geographic margins."

As a rule, neither of the two important malignant neoplasms of the testis is easily confused with tuberculosis, as the latter usually involves the epididymis and unless only the margin of the testis is involved, shows great liquefaction of the testicular tissue proper.

On the other hand, the luetic testis is at times likely to resemble the carcinomata. This *is very important* as in the literature there are reports of the removal of such testes and the subjection of the patient to the radical operation by mistake.

Grossly the diagnosis can usually be made by a competent observer. It is well however to have a frozen section made. The interpretation of frozen sections however is at times difficult, especially the differentiation between carcinoma and gumma, or luetic testis without gummatous areas. The presence of glands, cartilage, etc., in the embryomata makes their diagnosis by frozen section easier.

Having decided that one is not dealing with tuberculosis or syphilis, the surgeon changes his gloves, etc., and proceeds.

The incision is extended in a curved manner so as to follow the course of the iliohypogastric and ilioinguinal nerves.

Paraphrasing Hinman, the incision is extended upward from the upper end of the high inguinal incision in the line of the outer border of the rectus muscle, for a short distance; it then curves outward toward a point about a centimeter below the tip of the twelfth rib, and follows along the lower border of that rib for half its length.

The external oblique fibers are merely separated by the scalpel; the internal oblique, transversalis and a small part of the fibers of the latissimus dorsi must be cut across. Only the iliac branch of the iliohypogastric nerve is to be sacrificed, the hypogastric branch being spared.

The peritoneum with the intestines within it is pushed inward away from the posterior abdominal parietes. The ureter, the spermatic vessels and lymphatics strip up with the peritoneum, but the lymph nodes remain upon the aorta and cava. In

removing the lymph nodes it is easier to work from below upward but it is better to ligate the spermatic vein and artery above if possible. It may be necessary to ligate the inferior mesenteric vessels if the glands are matted together around them, and in animals ligation of these vessels has done no harm.

Rubber tubes with an exit from the back can be used for carrying radium for twelve to fourteen hours after operation.

The closure of the wound should be a hernioplasty.

RESULTS OF THE RADICAL OPERATION

The primary surgical mortality is of most import in an operation of this sort.

The operation was first performed in 1906.

Cairns in 1926 reported 17 cases done at the London Hospital without mortality. This is the only series in the literature without primary mortality.

Hinman in 1923 reported 79 cases from the literature, of which 9 were personal cases. Of these 79 patients operated by various surgeons, the mortality was 10 patients, or 13 per cent. In Hinman's own personal cases, one died from operation, 11 per cent.

Dew's experience is three operations with no deaths; one of these was not completed on account of the finding of irremovable masses.

THE CURE

A four-year period without recurrence is not enough, but most authorities agree upon a six-year period.

Dew says that barely 60 per cent of the cases seen appear to justify the operation and in Hinman's collection of 79 cases, 22 which were submitted to operation were found to be inoperable after the surgical exposure was made. The operation was really successfully done in only 57 of the 79 patients.

In 24 of Hinman's patients in whom metastases were found and removed, 6 died later of metastases; 1 was accidentally killed; 15 survived (4 of them more than four years). All of these would have died of cancer without surgery or with mere orchidectomy.

In 25 of Hinman's patients in whom the pathologist could find no malignancy in the lymphatic areas removed, 8 died of metastases; 1 was untraced; *but* 13 *are living*. Some of these 13 might have survived with mere orchidectomy.

A comparison of these figures with those of mere orchidectomy, even with an operative mortality of more that 10 per cent is *in favor of the radical operation.*

RADIOTHERAPY WITH OR WITHOUT SURGERY

Barringer and Dean report from the Memorial Hospital studies which are suggestive. Their cases are too few in number and not followed to the six-year period, but if they prove satisfactory, they will give better results than the radical operation has shown, to say nothing of having eliminated the mortality of the radical operation.

Dean advises high voltage *x*-ray to the loin and low voltage *x*-ray to the scrotum; this is continued for three or four weeks. Then a careful orchidectomy is done. Postoperative radiation treatment is then continued for three to four months or even longer.

Of 39 patients who had orchidectomy done before they came to Memorial Hospital and in which recurrence was present:

24 are dead

7 are lost to record

8 are alive; 4 over four years and the longest seven years and seven months.

Of 6 primarily operated cases, which were considered to be operable:

1 patient died of metastases in ten months

1 was not followed longer than fifteen months

4 were alive thirteen to forty-five months.

These figures are *very suggestive*, although they are suggestive merely until we amass more cases and studies over longer periods.

CONCLUSIONS

1. That for practical purposes neoplasms of the testicle are all malignant, the malignant embryomata being somewhat more malignant than the spheroidal cell carcinomata.

2. That sarcoma of the testicle is among the rarest of testicular neoplasms.

3. That the route of metastasis is usually lymphatic.

4. That simple castration is of little avail, curing only about 5 per cent of cases that are followed four to six years.

5. That the radical operation seems to give a considerably higher percentage of cures, even discounted by its primary surgical mortality.

6. That before deciding on the radical operation, the testicle should be studied in the operating room jointly by the surgeon and pathologist, grossly and microscopically, following a certain carefully described technique.

7. That preoperative and postoperative radiation in conjunction with careful castration may be the hope of the future, but not enough material has so far been recorded to decide in favor of this technique.

Thanks are due Dr. A. A. Eisenberg, Director of Laboratories, and to the Surgeons of Sydenham Hospital for the use of the material.

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PERFORATED PEPTIC ULCER*

A STATISTICAL AND ROENTGENOLOGICAL STUDY OF 82 CASES

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FROM 1917 to 1930 (both years inclusive) there were operated upon at St. Luke's Hospital 82 patients with perforated peptic ulcers.

ETIOLOGY

Of these cases, 72 were males and 10 females (Table I). The greatest age incidence was in the two decades between thirty-one and fifty with the decades preceding and following this period showing slightly more than half the ten-year occurrence in the period just given. The youngest patient was three years old and the oldest sixty-nine.

TABLE I

SEX AND AGE

		Per Cent
Males	72	87.8
Females	10	12.2

Age in years	1–10	11–20	21–30	31–40	41–50	51–60	61–
Number	1 (3 yrs.)	4	13	24	20	14	6
Per cent	1.2	4.8	15.8	29.5	24.4	17.0	7.0

Total cases, 82. (Two with 4-plus Wassermann reactions.)

The occupations covered by the patients included in this series covered a very wide range. However, an incidence of nearly 10 per cent in chauffeurs appears to be far out of proportion. This can possibly be accounted for by their irregular hours of eating and, often, their great rush in poor restaurants. The other occupations included in the list occur approximately in the same proportion as their incidence in the general population.

Focal infection probably plays a large part in the etiology. Bad teeth are noted frequently, and often infected tonsils, but their presence or absence was not noted with sufficient regularity to justify any statistical conclusions. Two cases had a 4-plus Wassermann reaction in the blood.

HISTORY

The statement has often been made that before operation in these cases previous indigestion is frequently denied but that nearly always after operation careful questioning reveals a definite indigestion history. The preoperative histories of these cases were positive for previous indigestion in 75 cases, negative in 6 and one not given. The duration of indigestion history is shown in Table II. Sixty-six patients had had indigestion for a period of two months or longer.

TABLE II

HISTORY OF INDIGESTION

75 positive, 6 negative, 1 not stated

Duration	3–7 Days	8–14 Days	15–30 Days	31–45 Days	46–60 Days	2 Mo. or over
Number	4	2	1	1	1	66

The period from the time of perforation to admission into the hospital is given in Table III. Two cases perforated while in

TABLE III

HOURS FROM PERFORATION TO ADMISSION*

Hours	–6	7–12	13–24	25–48	49–72	73–96	Longer Period	Not Stated
Total cases	30	11	6	4	6	2	19	3
Lived	28	10	4	3	3	1	14	2
Died	2	1	2	1	2	1	5†	1
Mortality,‡ per cent	6.7	9	33	25	33	50	26.3	66

* If in hospital from perforation to operation.

† One perforated after gastroenterostomy for duodenal ulcer—died. Had perforated also a long time before according to operative findings.

‡ Total mortality, 18.3 per cent.

* Submitted for publication October 24, 1931.

the hospital under ulcer treatment. The duration for these two was figured from the time of perforation to the time of operation. One case perforated after a gastroenterostomy had been done for an ulcer in the first part of the duodenum. The mortality increased markedly with the increase in time elapsed between perforation and operation.

The immediate history in practically all of the acute perforations was classical. In those cases having perforated a considerable time before operation or when the perforation was extraperitoneal the histories were not typical. Sixty-five patients gave a history of sharp, sudden, severe onset of the pain. Sixteen reported moderate pain only. Forty had vomited while 6 were only nauseated. Sixty-nine had epigastric pain. The pain was generalized over the abdomen in 8 and localized in the right lower quadrant in 4. In 2 of the latter a diagnosis of ruptured appendix was made and the abdomen opened through a McBurney's incision. In the case which perforated postoperatively the patient complained of no more pain than that expected after an abdominal operation such as she had had. The perforation was found at autopsy. A case, similar in that it had no symptoms, has been reported by Gregoire.

PHYSICAL FINDINGS

As to physical findings, board-like rigidity was the most constant, being found in 56 cases. There was a slight rigidity in 25. Liver dulness was stated as obliterated in 12, as present in 12 and not stated in 61. Fluid in the flanks was demonstrated in 3 cases, noted as absent in 9 and not stated in 73. One case perforated postoperatively and had no physical findings referable to this condition. In 3 cases definite history and physical findings were not given.

PATHOLOGICAL FINDINGS

The site of perforation (Tables IV A and B) was in the first part of the duodenum in 57. The prepyloric region was the next most common site with 12, while the second part of the duodenum and upper portion of the stomach were much less frequent sites, their occurrence being 7 and 6 respectively.

TABLE IV A
SITE OF PERFORATION

Site	Stomach Upper	Stomach Lower	First Part Duodenum	Second Part Duodenum
Total cases	6	12	57	7
Lived	5	10	45	7
Died	1	2	12	0
Mortality, per cent	16.6	16.6	21.0	0

Fifty-one were found perforated into the free peritoneal cavity at the time of operation, with a mortality of 19.6 per cent. When the perforation had been sealed off the mortality was reduced to 12 per cent. This condition was found in 25 cases. The high mortality in those which had perforated retroperitoneally or into the pancreas was undoubtedly the result of the large, long and difficult operations performed on these patients. The presence or absence of fluid and gas corresponds to the physical findings when they were noted in the examination. The size of the perforation and the amount of induration apparently bore no relation to the history or physical findings.

TABLE IV B
SITE OF PERFORATION

Site	Perforation into Free Peritoneal Cavity	Perforation Sealed or Walled Off	Perforation Retroperitoneal or into Pancreas
Total cases	51	25	6
Lived	41	22	4
Died	10	3	2
Mortality, per cent	19.6	12.0	33.3

POSTOPERATIVE MORTALITY AND COMPLICATIONS

The total postoperative mortality for the 82 cases was 15, i.e., 18.3 per cent. The causes of death in relation to the site of perforation, time of perforation and the operation performed are shown in Table v. A severe peritonitis, noted as occurring in 8 cases, is the most frequent. With one exception this occurred even though the peritoneal cavity had been drained. Pulmonary complications occurred in 40 per cent

Table v
Postoperative Deaths

Time from Perforation to Operation	Pre-perforation Symptoms	Location of Perforation	Operation	Cause of Death	Time of Death
4 hours	10 years	1st part duodenum	Inversion	Lobar pneumonia both upper lobes. (Group III). Persistent thymus	6 days
5 hours	Many years	Stomach—lesser curvature near pylorus	Cauterized. Inversion. Posterior gastro-enterostomy	Lobar pneumonia, right lower	8 days
6 hours	Many years	1st part duodenum	Inversion. Posterior gastroenterostomy	Peritonitis. Urinary suppression	2½ days
9 hours	Many years	Upper third lesser curvature	Inversion. Anterior gastroenterostomy	Shock. Peritonitis	36 hours
24 hours	6 weeks	1st part duodenum	Inversion	Peritonitis	22 hours
24 hours	10 years	1st part duodenum	Inversion	Peritonitis	4 days
28 hours	10 months	1st part duodenum	Inversion	Peritonitis	2 days
72 hours (new 6 hours)	5 years	1st part duodenum	Inversion. Posterior gastroenterostomy	Shock. Peritonitis	36 hours
73 hours	Many years	1st part duodenum	Inversion	Shock. Peritonitis	4 hours
96 hours	6 years	1st part duodenum	Inversion. Jejunostomy	Bronchopneumonia (right lower). Localized peritonitis	13 days
2 months	5 months	1st part duodenum	Inversion. Posterior gastroenterostomy. Appendectomy	Pulmonary embolus	12 days
2 months ?	Many years	1st part duodenum	Billroth II	Duodenal fistula. Inanition	13 days
Old	4 years	Stomach, posterior pyloric region	Pólya resection	Bronchopneumonia	7 days
Old	10 years	1st part duodenum	Cauterized. Inversion. Posterior gastroenterostomy. Cholecystectomy	Pulmonary edema. Cardiac failure	24 hours
Old	32 years	1st part duodenum	Posterior gastroenterostomy	Postoperative reperforation. Peritonitis	12 days

of the fatal cases. The other causes of death do not seem different from those expected in any similarly dangerous list of operations.

The frequency of pulmonary complications (43.3 per cent of the total number of complications) seems quite remarkable (Tables VI and VII). The limitation of

TABLE VI

POSTOPERATIVE COMPLICATIONS
(Peritonitis not included)

Bronchopneumonia	6
Separation of wound	5
Duodenal fistula	3
Hemorrhage	3
Lobar pneumonia	3
Shock	3
Bronchitis	1
Cardiac failure	1
Massive collapse	1
Obstruction (high)	1
Pulmonary edema	1
Pulmonary embolus	1
Urinary suppression	1
Total	30

TABLE VII

PULMONARY COMPLICATIONS

	Number	Mortality, Per Cent
Bronchopneumonia	6	33.3
Lobar pneumonia	3	66.6
Pulmonary embolus	1	100.0
Pulmonary edema	1	100.0
Massive collapse	1	0.0
Bronchitis	1	0.0
Total	13*	46.0†

* This represents 43 per cent of all the complications and an incidence of 15.8 per cent in the total number of cases.

† This is 40 per cent of the total mortality and a mortality of 7.3 per cent of the total number of cases.

excursion of the diaphragm and reduced vital capacity are probably the two major factors in causing this high percentage. As would be expected bronchopneumonia and lobar pneumonia head the list of pulmonary complications. These complications (i.e., pulmonary) occurred in 15.8 per cent of all the cases with a mortality of 7.3 per cent or 40 per cent of the total mortality. Nearly every case had ether anesthesia. Local infiltration and field block might possibly have reduced these figures, but recent figures tend to show that pulmonary complications are at least as frequent after spinal or local anesthesia as after ether.

Separation of the wound occurred five times. This evidently indicates that more of the wounds should have been drained, at least to the peritoneum, and that those which were drained should have been drained more thoroughly. However this factor appears to have no relation to the mortality. Duodenal fistula occurred three times and caused one death by inanition. The other two closed spontaneously. Two of these occurred in cases in which at operation the perforation was thought to be sealed off securely and no attempt made at further closure. The remaining complications do not appear remarkable.

Peritonitis is not considered among the complications as all these cases have a contaminated peritoneum at the time of operation.

ULTIMATE PROGNOSIS

Of the 67 patients surviving operation, 59 were followed up for one year or more (Tables VIII A and B). Of these, 38 were followed for a period of five years or more, of which 28 had remained free from symptoms following the original operation up to the

TABLE VIII A

FOLLOW-UP

Lived	67
Followed up	59
Remaining free from symptoms	40
Per cent of followed with symptoms	32.2

Years followed	1	2	3	4	5	6	7	8	9	10	11	12	13
Remaining free from symptoms	3	4	1	4	3	8	6	4	2	3	0	1	1
With symptoms	3	1	3	2	2	3	1	1	0	0	1	2	0

TABLE VIII B

FIVE YEAR "CURES"

Cases followed 5 years or longer	38
Remaining free from symptoms	28
With symptoms	10
Percentage of 5 year "cures"	74*

* Not allowing reduction due to proportionate number of postoperative deaths.

time when last seen (i.e., 74 per cent five year "cures"). Of the other 10 patients some have been symptom-free for periods of less than five years from subsequent surgical procedures.

Among the 59 followed cases, 18 had recurrence of symptoms leaving 67 per cent remaining free from symptoms up to the time when last seen. Seven patients with a recurrence of symptoms subsequently had posterior gastro-enterostomies performed and none of these has had any return of symptoms after this, their second operation. Of the 3 patients operated on upon again later because of another perforation, two have had no further symptoms. The remaining 8 when last seen or at the present time, whichever the case might be, were controlled by diet and medication.

OPERATIVE PROCEDURES

Simple inversion (Table IX) was the operation performed the greatest number of times. The percentage of cases remaining free from symptoms was 44 per cent but the mortality was only 15.4 per cent. It must be recalled that the extremely bad risks are all automatically relegated to this list.

TABLE IX

TYPES OF ORIGINAL OPERATION

Operation	Total	Followed	Cured*	Symptoms	Deaths	Per Cent Cured*	Per Cent Mortality
Inversion alone	39	39	15	14	6	43.0	15.4
Inversion and cauterization	3	3	2	1	0	66.6	0.0
Inversion and gastroenterostomy	30	19	16	3	7	61.2	23.3
Excision alone	2	2	1	1	0	50.0	0.0
Excision and pyloroplasty	2	2	2	0	0	100.0	0.0
Excision and gastroenterostomy	2	2	2	0	1	100.0	0.0
Polya	3	2	2	0	1	66.6	33.3
Billroth II	1	..	..	..	1	0.0	100.0

* Cases not followed up excluded from totals in figuring percentage of cures. This gives a lower figure than is absolutely correct because only the proportionate number of deaths should be included. By cured is meant remaining free from symptoms up to the time when last seen.

Inversion plus posterior gastroenterostomy was the next most frequently used operation. The percentage of cases remaining free from symptoms was increased by nearly half but the mortality was likewise increased by half. When we consider that, of the 7 patients having a gastroenterostomy subsequent to a simple inversion, none died and none has had a recurrence of symptoms, the added cures by gastroenterostomy at the original operation by no means appear to justify the increased mortality.

The other operative procedures were used too infrequently for any conclusions to be drawn from their results.

ADDITIONAL SURGERY

The additional surgery (Table X) (i.e., not including that done on the stomach and duodenum) at the time of the original operation was performed as circumstances dictated. In 2 cases the gall bladder was so involved that it was removed. In 1 late case jejunostomy was performed because of an already present ileus, but with no apparent effect on the ultimate outcome.

TABLE X

ADDITIONAL SURGERY

(With Original Operation)

Inversion	
Plus jejunostomy for ileus	1
Died	1
Excision and pyloroplasty	
Plus cholecystectomy	1
Remaining free from symptoms	1
Inversion and gastroenterostomy	
Plus cholecystectomy	1
Died	1
Plus appendectomy	5
Remaining free from symptoms	3
With symptoms	1
Died	1

In 2 cases the appendix was removed when a McBurney incision was made because of a wrong diagnosis and before the upper rectus incision was made. The other 3 appendectomies were incidental when the surgeon felt the patient's condition permitted this procedure. The mortality of 20 per cent in the 5 cases having appendectomies is above the total when it

should have been lower as the operation was performed on supposedly better risks. This again argues in favor of the least possible surgery at the time of the original operation.

SUBSEQUENT OPERATIONS

Subsequent operations (Tables XI A, B, C and D) were performed fourteen times on 12 patients. Seven of these were posterior gastroenterostomies for a recurrence of symptoms with complete relief to the present time in all. One of the cases developed a postoperative obstruction for which a jejunostomy was done with relief of the obstruction and no return of symptoms to the present time.

Three cases perforated a second time. Two of these patients had simple inversion and of these one has remained symptom-free. The third patient had an excision with closure and remained symptom-free for three years following the second operation. The two perforations were at the same site in the duodenum. At the third operation, done for a recurrence of symptoms, a prepyloric ulcer was found and a gastroenterostomy performed. This patient has had no symptoms since. This is the only patient with a record of the recurrence being at a different site.

The other two operations were, one for hemorrhage three weeks postoperative and one for marginal ulcer seven years after the original operation.

TABLE XI A

SUBSEQUENT OPERATIONS

Posterior Gastroenterostomy for Return of Symptoms*

Time after First Operation	Original Operation	Site of Perforation	Ulcer Causing Symptoms
6 months.....	Inversion	2nd part duodenum	Same
10 months....	Inversion	Prepyloric	Same
18 months†...	Inversion	1st part duodenum	Same
19 months....	Inversion	1st part duodenum	Same
2½ years.....	Inversion	1st part duodenum	Same. 2 ulcers palpated
5 years and 3 years‡.....	Excision	1st part duodenum	Prepyloric
Several years..	Inversion	1st part duodenum	Same

* All seven have remained free from a return of ulcer symptoms.

† Temporary duodenal fistula. Jejunostomy for obstruction with complete and permanent relief.

‡ Ulcer excised and closed at two previous perforations both at the same site.

TABLE XI B

SUBSEQUENT OPERATIONS

For Reperforations

Time after 1st Operation	Original Operation	Site of 1st Perforation	Site of 2nd Perforation	Operation	Result
1 year.....	Inversion	1st part duodenum	Same	Inversion	Slight symptoms
1 year.....	Inversion	2nd part duodenum	Same	Inversion	Free from symptoms
20 months.	Excision	1st part duodenum	Same	Excision	Ulcer symptoms*

* Symptoms recurred three years later. Prepyloric ulcer found. Posterior gastroenterostomy resulted in no return of symptoms.

TABLE XI C

SUBSEQUENT OPERATIONS

For Hemorrhage and Continued Vomiting

Time after 1st Operation	Original Operation	Site of Perforation	Operation	Result
3 weeks....	Inversion	High on lesser curvature	Cauterization of ulcer. Plastic repair of hourglass deformity	Free from symptoms

TABLE XI D

SUBSEQUENT OPERATIONS

For Marginal Ulcer

Time after 1st Operation	Original Operation	Site of Perforation	Operation	Result
7 years....	Inversion and posterior gastroenterostomy	1st part of duodenum	Ulcer excised. Gastroenterostomy undone. Pyloroplasty	Slight symptoms. Controlled by hyperacidity routine

POSTOPERATIVE ROENTGENOGRAPHIC STUDIES (FIGS. 1–27)

This work was undertaken primarily to determine whether or not postoperative roentgen ray studies of these cases would differentiate cures and activity and foretell the probability of reperforation.

Of the 58 cases followed up, 33 have had postoperative roentgen ray examinations of the gastrointestinal tract one or more times. The majority showed a permanent irregularity or filling defect at the site of the perforated ulcer. Only those having a return of symptoms showed spasm and tenderness to pressure at the point of the deformity with hypermotility of the stomach.

NONOPERATIVE MORTALITY

But 2 patients followed up have died since leaving the hospital. One death occurred five years postoperative and was due to pulmonary and laryngeal tuberculosis. The other was a case which remained symptom-free for three years after inversion and posterior gastroenterostomy for a perforated gastric ulcer. This patient then returned with abdominal pain and vomiting. Examination revealed a large mass in the epigastrium which was diagnosed as gastric carcinoma by roentgenograms. No post-mortem examination was obtained. This was the only patient in the entire list who to date has returned with a gastric malignancy giving an incidence of 1.2 per cent.

RATIONALE OF TREATMENT

A review of the recent literature on the subject reveals a great disparity in the conclusions as to what the proper treatment of perforated peptic ulcers may be. A great number of surgeons, after years of careful follow-up studies of their cases and checking over their comparative mortality figures, lean more and more toward conservatism. On the continent a great many recommendations are put forward for gastric resection at the time of the original operation. The diverse procedures involving varying amounts of surgery between these two extremes are recommended frequently.

From this study the conclusion is made that the least possible surgery at the time of the original operation is very much worth while and results in a marked lowering of the mortality figure. Additional operative procedures should be left for a subsequent time and done when indications dictate. Such subsequent operations carry a much lower mortality than the amount they add to the original mortality figure. Our results show also that approximately 44 per cent of the cases will have no cause for later surgery and should be given the benefit of the freedom from the increase in mortality due to any additional surgery.

In case a pyloric stenosis or obstruction is found at the time of the original operation, a nasal (Levine) tube may be passed into the stomach and guided through the pylorus. This permits feeding until the time when the patient's condition permits a second operation.

Nothing is given for twenty-four hours postoperative and the diet is then ordered for the next ten days as in any gastric operation. Following that we feel it to be very much worth while to proceed with a regular ulcer treatment, Sippy, Bastedo or Lenhartz, as the operator may desire. From the time of discharge the patient should be under the careful observation of a competent gastroenterologist who regulates the subsequent care and determines the necessity for additional operative procedures.

Case Histories*

SIMPLE INVERSION OF ULCER

Case 1. (Dr. J. J. Westermann.) D. W., male, aged forty-five, was admitted on January 31, 1925. Six hours before admission he had a severe sharp sudden pain above the umbilicus which spread to the rest of the abdomen. He then vomited. For one week he had had a burning pain in the epigastrium relieved by

* Including only those which have had postoperative roentgenograms.

food. Examination showed board-like rigidity of the entire abdomen, with liver dulness present.

Immediate operation revealed a large amount of turbid fluid in the abdomen. On the anterior surface of the second portion of the duodenum was an indurated area 2.5 cm. in diameter, in the center of which was a 2 mm. perforation. The perforation was inverted and a tab of omentum turned over the suture line. The peritoneal cavity was drained.

Fig. 1. Case 11, five years and two months postoperative to simple inversion of perforation, 1 cm. beyond pyloric ring. Deformity of cap was constant. No symptoms since operation.

Fig. 2. Case 11, six years postoperative. Deformity of cap was constant. No symptoms since operation.

Convalescence was uneventful and the patient was discharged on February 16, 1925, without symptoms.

Postoperative roentgen ray examination on November 21, 1925, showed dilatation of the stomach with persistent irregularity of the duodenum. Peristalsis was hyperactive and at six hours there was no retention.

Another, on April 5, 1927, showed a persistent defect in the duodenum and the stomach empty at six hours.

On December 18, 1927 the stomach showed normal emptying with a constant defect in the duodenum.

On November 17, 1930 it appeared normal with a large smooth cap. No abnormality of the duodenum was noted.

The patient has had no return of symptoms since the operation.

Case 11. (Dr. J. J. Westermann.) M. M., male, aged thirty-six, was admitted on December 4, 1924, because of severe epigastric pain which had begun suddenly six hours before. He did not vomit. For the preceding three months he had had pain one to two hours after meals. Examination showed board-like rigidity of the upper abdomen with obliteration of the liver dulness.

Immediate operation revealed considerable bile-stained fluid and gas in the peritoneal cavity. One centimeter below the pyloric ring on the anterior surface of the duodenum was a 3 mm. perforation. The ulcer was excised by a longitudinal elliptical incision and the defect sutured transversely. A tab of omentum was drawn over the suture line and a rubber dam drain inserted into the peritoneal cavity.

Convalescence was uneventful and the patient was discharged without symptoms on December 21, 1924.

Postoperative roentgen ray examination on January 27, 1930 (Fig. 1) showed a large stomach, normal in shape and position. The peristalsis was deep and vigorous. The cap was

persistently irregular but without spasticity, tenderness or retention. This was the appearance of an old healed ulcer.

the suture line covered with a tab of omentum. No drain was used.

Convalescence was uneventful and the patient was discharged without symptoms on October 5, 1928.

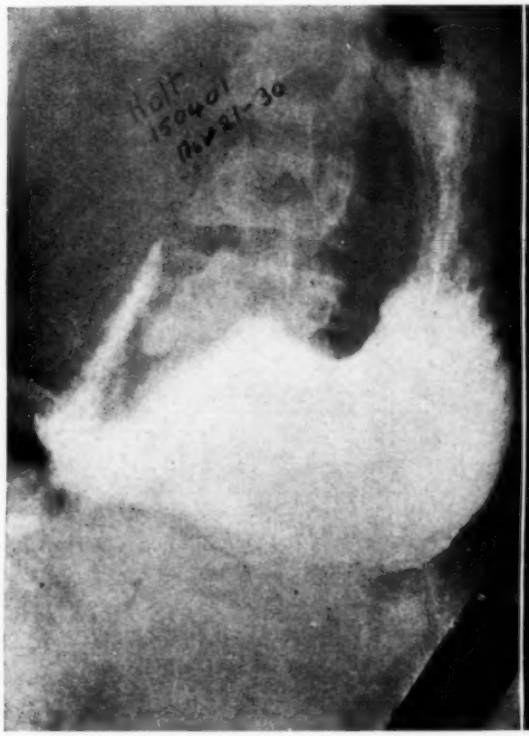

Fig. 3. Anteroposterior roentgenogram of Case v, seven months postoperative to simple inversion of perforated ulcer high on lesser curvature. Large perforating ulcer shows at site of original perforation. Mild ulcer symptoms.

Fig. 4. Oblique roentgenogram of Case v.

Another on December 8, 1930 (Fig. 2) showed the stomach normal with some constant deformity of the first portion of the duodenum. There was no spasticity. This indicated a healed process.

He has had no return of symptoms to the present time.

Postoperative roentgen ray examination on October 4, 1928 showed hyperperistalsis. The cap contained a permanent defect with considerable spasticity and tenderness. There was no six hour retention.

This patient continued to have epigastric pain before meals to the time when he was last seen one year after operation.

Case iii. (Dr. F. W. Solley.) M. L., male, aged forty-four, was admitted on September 18, 1928, because of severe pain in the epigastrium which had begun suddenly six hours before. He vomited. For several years he had had epigastric pain and gas two hours after meals. Examination showed board-like rigidity of the abdomen.

Immediate operation revealed a large amount of bile-stained fluid in the peritoneal cavity. On the anterior surface of the duodenum just past the pyloric ring was an indurated area 3 cm. in diameter with a 5 mm. perforation in its center. The perforation was inverted and

Case iv. (Dr. R. W. Bolling.) J. S., male, aged thirty-three, was admitted May 30, 1922. One and one-half hours before admission he had had a sudden severe pain in the epigastrium. For the preceding eight years he had had epigastric pain after meals, relieved by soda. Examination showed board-like rigidity but no fluid wave.

Immediate operation revealed only a small amount of fluid in the peritoneal cavity. In the anterior wall of the duodenum 3 cm. distal to the pyloric vein was a 3 mm. perforation. The perforation was inverted and the suture line covered with a tab of omentum.

During convalescence he had some indigestion and upon discharge on June 15, 1922, was referred to the stomach clinic.

FIG. 5. Case VI, eighteen months postoperative to simple inversion of perforation just beyond pyloric ring. Deformity of cap was constant. No symptoms since operation.

Postoperative roentgen ray examination on August 17, 1922 showed a normal stomach.

He had no symptoms from the time of discharge until last seen on October 4, 1923.

CASE V. (Dr. M. K. Smith.) C. H., male aged thirty-three, was admitted on May 3, 1930. Two and one-half hours before admission he had had a sudden severe sharp pain in the left upper quadrant. For the eighteen months preceding he had had pain in the epigastrium one hour after meals lasting two to three hours, relieved by alkaline powders or food. For two months he had had tarry stools. No vomiting occurred at any time. Examination showed tenderness and rigidity of the entire abdomen, board-like in the upper abdomen. Liver dulness was present and no fluid wave could be demonstrated.

Preoperative roentgen ray examination showed no gas beneath the diaphragm.

Immediate operation revealed an area of induration 5 cm. in diameter with a 5 mm. perforation in its center near the cardia on the lesser curvature. The left lobe of the liver was adherent to a part of the indurated area. The peritoneal cavity contained very little free fluid. The perforation was inverted and the suture line covered with a tab of omentum. No drains were used.

Convalescence was uneventful but for a post-operative temperature. *Roentgenograms showed a pneumonic process in the right lower lobe.*

He was discharged symptom free on May 25, 1930.

Postoperative roentgen ray examination on November 21, 1930 (Figs. 3, 4) showed a large perforating ulcer on the posterior wall of the stomach midway between the cardia and pylorus. There was no six hour retention.

Up to the present time the patient has continued to have mild ulcer symptoms even though he is on an ulcer diet.

CASE VI. (Dr. W. F. MacFee.) R. P., male, aged thirty-five, was admitted on March 7, 1929. One and one-half hours before admission he had had a sudden severe sharp pain above the umbilicus with nausea but no vomiting. He denied any previous gastrointestinal history. Examination showed board-like rigidity of the entire abdomen with obliteration of the liver dulness.

Immediate operation revealed considerable gas and some bile-stained fluid in the peritoneal cavity. Just beyond the pyloric ring was a 5 mm. perforation surrounded by a moderate amount of induration. The perforation was inverted and the abdomen closed without drainage.

A severe bronchitis developed and on the sixth day with a spasm of coughing the wound broke open. It was resutured and healed firmly. On April 3, 1929, he was discharged without symptoms.

Postoperative roentgen ray examination on December 8, 1930 (Fig. 5) showed a normal stomach. The duodenum contained a persistent deformity with no spasticity or tenderness.

The patient has had no return of symptoms up to the present time.

CASE VII. (Dr. H. J. Shelley.) M. P., male, aged thirty, was admitted on August 30, 1930. Seven hours before he had had a sudden severe epigastric pain which continued. This was associated with nausea but no vomiting. For six years he had epigastric pain one hour after meals. Examination showed

board-like rigidity, most marked in the right upper rectus. Liver dulness was present and there was no demonstrable fluid wave.

Fig. 6. Case vii, three months postoperative to simple inversion of perforation of first part of duodenum. Slight constant irregularity of cap. No symptoms since operation.

Immediate operation revealed a small amount of thick bile-stained fluid in the peritoneal cavity. The duodenum was adherent to the under surface of the liver. In the anterior surface of the first portion of the duodenum was a 3 mm. perforation surrounded by a small area of induration. The perforation was inverted and a tab of omentum turned over the suture line. The peritoneal cavity was drained.

Convalescence was complicated by a bronchopneumonia but the patient was discharged on September 30, 1930, without symptoms.

Postoperative roentgen ray examination on November 12, 1930 (Fig. 6) showed a regular stomach which emptied normally. Although there was no evidence of the site of the perforation, the cap did not have an entirely regular outline. No spasticity was noted.

He has had no return of symptoms up to the present time.

Case viii. (Dr. R. W. Bolling.) H. F., male, aged thirty, was admitted on March 21, 1923. Three hours before admission he had had a sharp sudden severe pain in the right lower quadrant with vomiting. For periods during the preceding ten years he had had pain in the epigastrium two hours after meals. In 1916 he had been on an ulcer diet for five months. Examination showed marked rigidity of the abdomen particularly in the epigastrium.

Fig. 7. Case viii, five years postoperative to simple inversion of perforation just beyond pyloric ring. Irregularity of cap was constant. No symptoms since operation.

Immediate operation revealed a small amount of viscous fluid in the peritoneal cavity, collected chiefly in the right lumbar gutter. Just distal to the pyloric vein was a large area of induration in the center of which was a 4 mm. perforation. The perforation was inverted and a tab of omentum drawn over the suture line. A rubber dam drain was inserted into the peritoneal cavity.

Postoperative roentgen ray examination on April 19, 1928 (Fig. 7) showed an irregular cap without spasm.

Another study on January 23, 1931 (Fig. 8) showed the stomach high and regular with active peristalsis. The cap was constantly irregular but with no spasm or retention.

The patient has had no return of symptoms up to the present time.

Case IX. (Dr. R. W. Bolling.) W. B., male, aged fifty-seven, was admitted on December 29, 1923. Two hours before he had had a sudden severe sharp pain in the epigastrium with nausea but no vomiting. For two weeks he had had epigastric discomfort every day about 5 P. M. Examination showed generalized board-like rigidity which was most marked in the right upper quadrant.

Fig. 8. Case VIII, seven years and ten months postoperative. Irregularity of cap was constant. No symptoms since operation.

Immediate operation revealed a considerable amount of bile-stained fluid in the peritoneal cavity. On the anterior surface of the first portion of the duodenum just distal to the pylorus was a 2 mm. perforation surrounded by only a moderate amount of induration. The perforation was inverted and the wound drained only down to the peritoneum.

Convalescence was uneventful and the patient was discharged without symptoms on January 20, 1924.

Postoperative roentgen ray examination on February 10, 1927, showed a sac in close relation to the duodenal cap which retained barium for twenty-four hours. This could have been a dilatation of the second portion of the duodenum. The cap filled fairly well.

Another study on January 22, 1931 (Fig. 9) showed a large stomach lying quite low. There was a pocketing of barium in the second portion of the duodenum which retained barium at the end of 6 hours (Fig. 10). This could be a diverticulum.

He has had no symptoms other than a moderate grade of constipation since the operation.

Case X. (Dr. F. W. Solley.) J. D., male, aged twenty-two, was admitted on June 22, 1926. One hour before admission he had had a sharp sudden severe pain about the umbilicus without vomiting. For the two weeks preceding he had had epigastric pain one to two hours after meals with vomiting. Examination showed board-like rigidity, most marked in the upper abdomen.

Immediate operation revealed only a small amount of fluid in the peritoneal cavity. On the anterior surface of the duodenum, just distal to the pylorus was an indurated area 3 cm. in diameter with a 5 mm. perforation in its center. The perforation was inverted. No drainage was used.

Convalescence was complicated by bronchopneumonia but the patient left the hospital on July 9, 1926, without symptoms.

Three months later he returned with a recurrence of the ulcer symptoms.

Postoperative roentgen ray examination on September 28, 1926, showed a small amount of gastric retention. There was slow emptying through the duodenum and jejunum. About the duodenum were evidences of adhesions and it did not fill evenly.

The patient continued to have symptoms, which were relieved by ulcer management, to the time last seen about a year after the operation.

Case XI. (Dr. R. W. Bolling.) C. H., male, aged twenty-eight, was admitted on July 1, 1922. Two days before he had had an acute sudden pain in the right upper quadrant radiating to the back and right shoulder. He vomited. The pain continued to the time of admission. One year previously he had had pain in the epigastrium one to two hours after meals relieved by soda. Examination revealed marked generalized rigidity particularly in the right upper quadrant.

Roentgenographic examination of the abdomen showed no gas bubbles.

Operation was deferred to July 3, 1922, when

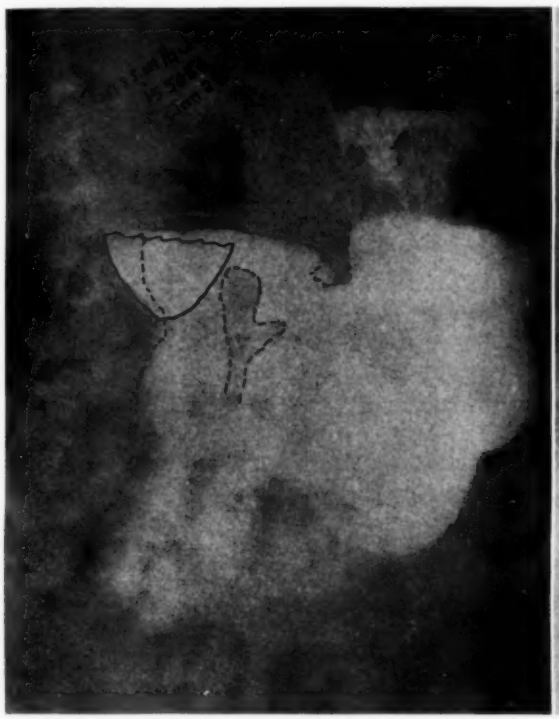

Fig. 9. Case IX, seven years postoperative to simple inversion of perforation just beyond pyloric ring. Pocket of barium shows beyond cap. This was a constant finding. No symptoms since operation.

Fig. 10. Six hours after Fig. 9 (Case IX). Barium still present in pocket noted in Fig. 9. This is probably a false diverticulum. No symptoms since operation.

it revealed the omentum plastered over the gall bladder and pyloric regions. The gall bladder was normal except for the fresh adhesions. On the anterior surface of the first portion of the duodenum 3 cm. beyond the pylorus was a 3 mm. perforation about which there was very little induration. The perforation was inverted and a drain inserted down to the fascia only.

Convalescence was uneventful and the patient was discharged on July 22, 1922, without symptoms.

Postoperative roentgen ray examination on January 17, 1923, showed irregularity of the cap but no retention. The stomach was normal.

Another examination on January 8, 1928, showed a persistently irregular cap. The stomach was normal and there was no retention.

The patient has had no return of symptoms up to the present time.

Case XII. (Dr. R. W. Bolling.) D. K., male, aged twenty-eight, was admitted on January 29, 1922. Six hours before admission he had had a sudden severe stabbing pain over the entire abdomen and had vomited bloody fluid. Eight hours before this attack he had had a fairly severe attack of pain which was relieved by soda. For several years he had had epigastric pain forty-five minutes after meals relieved by soda or food, and during that time he had noticed tarry stools. Examination showed board-like rigidity of the abdomen particularly in the right upper quadrant.

Immediate operation revealed a moderate amount of free gas and fluid in the peritoneal cavity. On the anterior surface of the first portion of the duodenum 4 cm. beyond the pyloric vein was a 3 mm. perforation. This was inverted and the peritoneal cavity drained.

Convalescence was uneventful and the patient was discharged without symptoms on February 16, 1922.

Postoperative roentgen ray examination on January 17, 1924, showed a large stomach with a constant duodenal deformity but no retention.

Another examination on March 6, 1925 showed a constant duodenal deformity without retention.

The patient had had no symptoms except slight indigestion immediately after heavy drinking bouts up to the time last seen in 1928.

Case xiii. (Dr. R. W. Bolling.) W. McD., male, aged forty-two, was admitted on February 24, 1927, because of a bleeding duodenal ulcer with considerable severe pain in the right upper quadrant. For one year he had had epigastric distress two to four hours after meals with nearly constant pain in the right upper quadrant which was relieved by vomiting. On the third day in the hospital he had a sudden sharp severe pain in the epigastrium and developed board-like rigidity and vomiting.

Immediate operation revealed a moderate amount of bile-stained fluid in the peritoneal cavity. The gall bladder was bound down to the first portion of the duodenum by dense firm adhesions. At this point was a large area of induration with a 7 mm. perforation partly closed by the gall bladder. Closure was completed by a combination of inversion and covering over with the gall bladder. A posterior gastroenterostomy was done and a rubber dam drain inserted down to the fascia.

Convalescence was uneventful and the patient was discharged on March 18, 1927, without symptoms.

Postoperative roentgen ray examination on October 5, 1928, showed rapid and complete emptying through the gastroenterostomy with a very narrow irregular duodenum.

He has had no return of symptoms up to the present time.

Case xiv. (Dr. R. W. Bolling.) C. P., male, aged forty-five, was admitted on August 27, 1919. One hour before he had had an intense sudden epigastric pain with distention of the abdomen. For three weeks he had had pain in the epigastrium one hour after meals. He vomited with the present attack. Examination showed board-like rigidity, generalized tenderness and the liver dulness obliterated.

Immediate operation revealed considerable fluid and gas in the peritoneal cavity. Three centimeters beyond the pyloric ring on the anterior surface of the duodenum was a 1.5 cm. area of induration with a 2 mm. perforation. The perforation was inverted and a drain inserted down to the peritoneum.

Convalescence was uneventful and the patient was discharged on September 14, 1919, without symptoms.

Postoperative roentgen ray examination on January 25, 1923, showed normal emptying but the cap was not outlined.

Up to the time he was last seen in June 1926, he had had no return of symptoms.

Case xv. (Dr. E. D. Truesdell.) J. T., male, aged thirty-three, was admitted December 12, 1923. Two days before he had had a sudden severe pain in the epigastrium. The pain continued and he had vomited. For two years he had had epigastric pain several hours after meals relieved by food. Examination showed a very rigid tender abdomen. Liver dulness was present but there was shifting dulness in the flanks.

Immediate operation revealed a large amount of bile-stained fluid in the peritoneal cavity. Near the lesser curvature 5 cm. above the pylorus was a 5 mm. perforation. This was inverted and a tab of omentum brought across the suture line. A soft rubber dam drain was inserted.

Convalescence was uneventful.

On January 1, 1924 a roentgenographic examination was made outside of the hospital and diagnosed duodenal ulcer.

He was readmitted on February 3, 1924. *Roentgenograms of the chest showed pulmonary tuberculosis and the sputum was positive.*

Postoperative roentgen ray examination on February 5, 1924, showed active peristalsis and no six hour retention. The duodenal cap was constantly deformed.

The patient was discharged on February 12, 1924, on ulcer treatment and management of the pulmonary tuberculosis.

On September 15, 1924 he was readmitted because of continued ulcer symptoms and pulmonary and laryngeal tuberculosis.

Postoperative roentgen ray examination on September 20, 1924, showed hyperperistalsis. There was a definite and constant defect in the cap.

He was discharged September 22, 1924, and continued to be troubled by gas after meals.

He died of the tuberculosis on September 27, 1928.

EXCISION AND PYLOROPLASTY

Case xvi. (Dr. J. Douglas.) M. McM., male, aged thirty-six, was admitted on October 15, 1924. Six days before he had had a sudden severe pain in the upper abdomen. Examination showed marked rigidity of the right upper rectus with a tender mass in this region. He

was watched for nine days with a diagnosis of acute cholecystitis.

Operation on October 24, 1924, revealed a well walled-off abscess between the liver, gall bladder, colon and duodenum. On the anterior superior aspect of the first portion of the duodenum was a perforation surrounded by a moderate amount of induration. In the abscess cavity were about 2 oz. of pus. The ulcer was excised and a Horsley pyloroplasty done.

Convalescence was uneventful and the patient left the hospital on November 19, 1924 without symptoms.

Postoperative roentgen ray examination on November 19, 1924, showed a stomach with normal motility. It emptied normally. About the pylorus and cap regions was slight but persistent irregularity.

He has had no return of symptoms up to the present time.

PERFORATION AFTER PREVIOUS EXCISION

Case xvii. (Dr. F. S. Mathews.) M. P., male, aged fifty-four, was admitted September 14, 1924, because of severe abdominal pain of twenty-four hours duration. He had vomited blood and had noticed tarry stools. For the three weeks preceding he had had severe pain in the right side of the abdomen not related to meals. Beginning five years before admission he had had intermittent attacks of epigastric pain after meals which was relieved by soda or food. Eighteen months before admission he had been operated upon at another hospital with a diagnosis off gastric ulcer. The stomach and gall bladder were reported normal and an appendectomy done. This had given no relief. Examination showed a tender rigid epigastrium with a marked anemia. A transfusion was done and the patient was transferred to surgery.

Operation was done on September 29, 1924. A large ulcer was found with a large crater at about the middle of the lesser curvature with a moderate amount of induration. The gall bladder was edematous and contained several faceted stones. It was subacutely inflamed. The ulcer was excised, a cholecystectomy done and the cystic duct drained. A transfusion was given before the patient left the table.

Convalescence was uneventful except for a "sour stomach" and epigastric discomfort relieved by soda and hyperacidity diet. The patient was discharged on October 26, 1924.

Postoperative roentgen ray examination on

Fig. 11. Case xvii, five years and eight months postoperative to excision and posterior gastroenterostomy for perforation high on lesser curvature. Constant hourglass deformity showed at site of gastroenterostomy. No symptoms since operation.

November 3, 1924, showed an hourglass stomach with definite irregularity at the site of the old ulcer. There was considerable six hour residue.

After operation he continued to have epigastric distress and burning eructations which were improved by ulcer treatment. Because of continued pain he was readmitted on March 24, 1925.

Roentgen ray examination on March 26, 1925, showed no hourglass deformity. The lesser curvature contained a sharply defined semicircular projection. The cap did not fill out well. There was considerable six hour retention.

Operation on March 30, 1925, revealed a large indurated thick walled ulcer high up on the lesser curvature. It was adherent to the under surface of the liver with a 1 cm. perforation in its center opening into a cavity, the walls of which were made up by the liver.

The ulcer was excised, a posterior gastroenterostomy done and the abdomen closed without drainage.

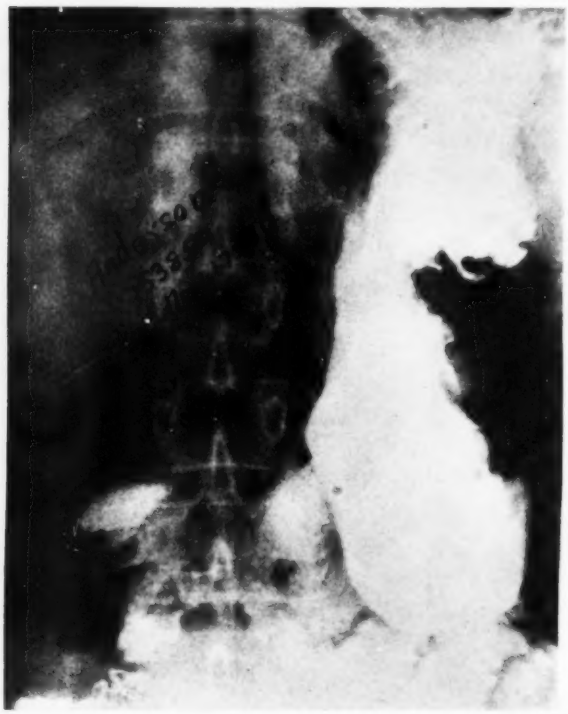

Fig. 12. Case xviii, eight years and ten months after a Pólya resection for perforation of first part of duodenum. No symptoms since operation.

Convalescence was uneventful and the patient was discharged without symptoms on April 17, 1925.

Postoperative roentgen ray examination on April 16, 1925, showed a small residue at six hours distal to the gastroenterostomy opening. The ulcer was not mentioned as showing.

In 1926 he was operated upon for fistula in ano, but had had no gastric symptoms.

Postoperative roentgen ray examination on October 27, 1930 (Fig. 11), showed a considerable hourglass deformity at the site of the gastroenterostomy. Emptying was rapid. No evidence of active ulceration was noted.

The patient has had no return of symptoms since the last operation up to the present time.

OLD PERFORATIONS

Case xviii. (Dr. W. A. Downes.) A. A., female, aged thirty-nine, was admitted on December 17, 1921, because of "coffee-ground" vomitus for the three preceding days. For eighteen months she had had epigastric pain fifteen to thirty minutes after meals relieved by soda or induced vomiting. She had vomited food eaten at considerable periods previously. Examination showed only a slight tenderness and rigidity in the epigastrium.

Roentgen ray examination three months before admission was reported gastroptosis only. Another on December 27, 1921, showed an extreme grade of dilatation of the stomach suggestive of pyloric stenosis. It emptied slowly but there was no six hour residue.

On ulcer treatment the pain in the epigastrium became gradually more severe and continuous.

Roentgen ray examination on January 15, 1922, showed the stomach still markedly dilated. There was irregularity about the pyloric end of the stomach and beside the first portion of the duodenum was a pouch-like structure which filled with barium. The pyloric end of the stomach was unusually far to the right. This had the appearance of a perforated ulcer.

Operation on January 18, 1922, revealed dense perigastric adhesions near the pylorus. The duodenum was large and dilated. On the posterior surface of the first portion of the duodenum was an indurated ulcer with a central perforation and a rather large cavity in the pancreas. A Pólya resection was done and the abdomen drained at McBurney's point.

Convalescence was uneventful and the patient was discharged symptom-free on February 4, 1922.

Postoperative roentgen ray examination on February 24, 1922, showed the stomach almost entirely to the left of the midline. The lower portion showed some irregularity. Emptying occurred at a fair rate and there was only very little retention at five hours.

Postoperative roentgen ray examination on November 17, 1930 (Fig. 12), showed some deformity along the great curvature with the stomach situated on the left side of the abdomen. It emptied readily through the gastroenterostomy.

The patient had no return of symptoms to the present time.

Case xix. (Dr. W. A. Downes.) W. C. D., male, aged thirty-six, was admitted on September 11, 1925, because of pain in the epigastrium and vomiting several hours after meals. He had had a chancre and salvarsan treatment in 1911. On his admission his Wassermann reaction was reported plus-minus with the cholesterol antigen and negative

with the acetone antigen. Examination showed only moderate tenderness and rigidity in the epigastrium.

Roentgen ray examination on September 15, 1925, showed a rather prominent niche at the edge of the lesser curvature, just above the pylorus.

Operation on September 25, 1925, revealed on the anterior surface of the duodenum just beyond the pylorus a reddened and thickened area 2.5 cm. in diameter. Opposite this on the posterior wall was a large ulcer which had perforated into the pancreas. The pancreas was markedly indurated about the cavity.

The ulcer bed in the pancreas and the edges of the perforation were cauterized. The perforation was closed with chromic sutures. The incision in the anterior wall of the duodenum was closed in the usual manner. A short-loop posterior gastroenterostomy and an appendectomy were then done.

Convalescence was uneventful and the patient was discharged without symptoms on October 7, 1925.

Postoperative roentgen ray examination on November 10, 1930 (Fig. 13) showed a stomach which filled readily. The cap was constantly irregular. The stomach emptied readily through the gastroenterostomy and at six hours there was no retention.

He has had no return of symptoms up to the present time.

Case xx. (Dr. W. A. Downes.) H. H., male, aged fifty-five, was admitted on September 25, 1922, because of pain and pressure in the epigastrium which began suddenly five days before admission. He had vomited five to six times daily a "coffee-ground" material. The first similar attack had occurred three years before and he had had six in the intervening time. For fifteen years he had had indigestion with epigastric pain two hours after meals, relieved by food or soda. Examination showed considerable tenderness and rigidity of the upper rectus muscles.

Roentgen ray examination on September 27, 1922, showed the lungs negative. In the prepyloric region was a filling defect with a pouch-like projection from the stomach. The stomach emptied in six hours.

This examination was repeated on September 29, 1922, and the same condition was found.

Operation on October 6, 1922, revealed the anterior surface of the stomach adherent to the abdominal wall by dense fibrous adhesions. On the anterior surface of the stomach just above the pylorus was a healed ulcer. In the middle of the lesser curvature was a perforated

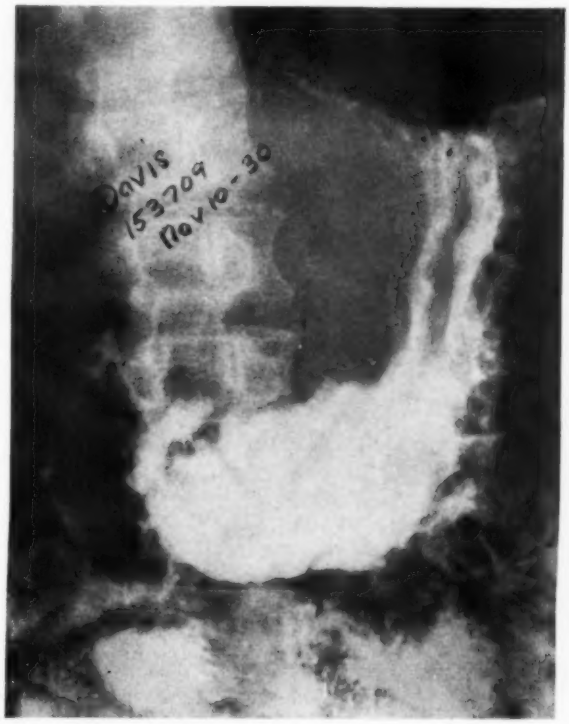

Fig. 13. Case xix, five years postoperative to cauterization and closure of perforation of first part of duodenum, and posterior gastroenterostomy. Irregularity of cap was constant. No symptoms since operation.

ulcer with a cavity extending toward the tail of the pancreas. The perforation was inverted and a posterior gastroenterostomy done.

Convalescence was uneventful and the patient left the hospital on October 25, 1922, without symptoms.

On October 30, 1925, he returned because of continuous epigastric pain. He had been entirely symptom-free in the interim.

Examination showed an orange-sized mass in the epigastrium.

Roentgen ray examination on November 9, 1925, showed a large filling defect in the lower end of the stomach to which the jejunum was attached. This was diagnosed gastric carcinoma.

He died on November 28, 1925 but no autopsy was obtained. This is the only case in this series among those followed up which has developed carcinoma.

IN ERSION AND GASTROENTEROSTOMY

Case xxi. (Dr. E. D. Truesdell.) B. F. B., male, aged forty-two, was admitted September

17, 1918, because of pain in the right lower quadrant. It had begun suddenly twelve hours previously with vomiting. For ten

Fig. 14. Case xxi, twelve years postoperative to simple inversion of perforation on stomach side of pylorus with posterior gastroenterostomy. Irregularity which shows in cap was not constant. It filled under fluoroscope. No symptoms since operation.

years he had had pain in the epigastrium one-half hour after meals which was relieved by food. Examination showed marked generalized board-like rigidity.

Immediate operation revealed an abscess cavity over the pylorus made up of omentum and stomach wall. On the anterior surface of the stomach near the pylorus was an ulcer with a perforation in its center. This was inverted and a posterior gastroenterostomy done.

Convalescence was uneventful. He was discharged without symptoms on September 25, 1918.

Postoperative roentgen ray examination on October 24, 1930 (Fig. 14) showed the gastroenterostomy functioning. There was some emptying through the duodenum but no evidence as to the site of the old ulcer.

The patient has had no return of symptoms up to the present time.

Case xxii. (Dr. M. K. Smith.) A. Z., male, aged eighteen, was admitted on May 12, 1925. Twenty-four hours previously he had had a sudden severe pain in the right lower quadrant. For years he had had intermittent "stomach aches" every three to four months and lasting a few hours. For the two weeks preceding admission he had had an attack daily.

Examination showed board-like rigidity particularly in the right upper quadrant and epigastrium. Liver dulness was present.

Immediate operation revealed a small amount of purulent appearing fluid in the peritoneal cavity. About the pylorus was a heavy deposit of fibrin. There was an indurated area in the first portion of the duodenum but it was not exposed as it was thought to be sealed off. A posterior gastroenterostomy was done and the peritoneal cavity drained.

Convalescence was complicated by a duodenal fistula which healed spontaneously. Immediately postoperative there was a massive collapse of the right lung from which recovery was complete. On June 13, 1925, he was discharged without symptoms.

Postoperative roentgen ray examination on November 12, 1930 (Fig. 15), showed no evidence of the site of the perforation. The stomach emptied rapidly through the gastroenterostomy.

The patient has had no recurrence of symptoms up to the present time.

Case xxiii. (Dr. R. W. Bolling.) H. S., male, aged thirty-seven, was admitted on April 2, 1923. He had had pain in the epigastrium and vomiting for ten years. The pain occurred a few hours after meals and was relieved by vomiting or soda. The vomitus often contained food eaten the day before. He had been on bismuth and alkalis for six years. Examination showed tenderness below the ensiform and large peristaltic waves.

On April 4, 1923, he had a sudden severe sharp epigastric pain. His abdomen developed board-like rigidity.

Operation three hours after the onset revealed a large amount of dark brown watery fluid in the peritoneal cavity. On the upper surface of the duodenum near the pylorus was a large area of induration and scarring in the center of which was a 1 cm. perforation. The pylorus was almost completely obstructed. The perforation was inverted and a tab of omentum drawn over the suture line. A posterior gastroenterostomy was done and a drain inserted to the peritoneum only.

Convalescence was uneventful and the patient left the hospital on April 22, 1923, without symptoms.

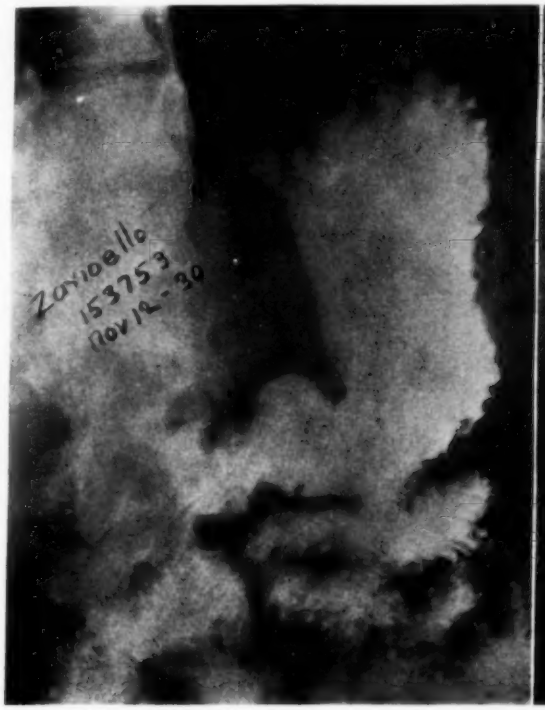

Fig. 15. Case xxii, five years and six months postoperative to posterior gastroenterostomy for perforation of first part of duodenum. Perforation was thought to be sealed by adhesions, but duodenal fistula developed which closed spontaneously. Cap was regular under fluoroscopic examination. No symptoms since operation.

Fig. 16. Case xxiii, seven years and eight months postoperative to simple inversion of perforation just beyond pyloric ring with posterior gastroenterostomy. Cap was regular in outline under fluoroscope. No symptoms since operation.

Postoperative roentgen ray examination on April 25, 1923, showed a large stomach which emptied at the normal rate through the gastroenterostomy opening. There was no retention. No mention was made of the duodenum.

Another on November 21, 1930, (Fig. 16) showed no evidence of the site of the perforation. The stomach emptied both through the duodenum and gastroenterostomy.

He has had no return of symptoms up to the present time.

Case xxiv. (Dr. R. W. Bolling.) J. K., male, aged thirty-nine, was admitted on January 7, 1920. Six hours before he had had a sudden severe attack of pain in the entire abdomen. He was nauseated and induced vomiting. For the preceding five weeks he had had attacks of epigastric pain two hours after meals which were partly relieved by soda. Three days and one day before admission he had had severe attacks of pain relieved by vomiting. Examination revealed tenderness and board-like rigidity especially in the right upper quadrant with obliteration of liver dulness.

Immediate operation revealed a small amount of turbid fluid and considerable gas in the peritoneal cavity. About the pylorus was a considerable deposit of fibrin. On the anterior surface of the first portion of the duodenum was an indurated area 2.5 cm. in diameter with a 4 mm. perforation in its center. This was closed by fibrinous adhesions to adjacent structures which freed readily. The induration gave an obstruction of the pylorus which was nearly complete. The perforation was inverted and a posterior gastroenterostomy done. The peritoneal cavity was drained.

Convalescence was uneventful except for some distress after taking food. He was discharged on January 26, 1920.

He was well for nearly two years when ulcer symptoms returned but were controlled by hyperacidity diet.

Postoperative roentgen ray examination on May 24, 1923, showed a normal stomach which emptied readily. The duodenum was irregular with delay in the ileum. No emptying was visualized through the gastroenterostomy opening.

FIG. 17. Case XXIV, nine years and six months postoperative to simple inversion of perforation of first part of duodenum with posterior gastroenterostomy. Defect in cap was constant. No symptoms for five years but had some four years postoperative.

The symptoms continued but were controlled by alkalis and mineral oil.

Another roentgen ray examination in 1924 showed a normal stomach. The cap did not fill but the stomach emptied at or near the pylorus. The gastroenterostomy opening was not visualized.

Roentgen ray examination on June 12, 1929 (Fig. 17), showed a normal stomach. There was a constant filling defect in the cap. The gastroenterostomy opening was not definitely visualized.

Roentgen ray examination on January 28, 1931 (Fig. 18), showed a normal stomach with active peristalsis. There was narrowing in the region of the cap. Emptying was normal with no six hour retention. Some emptying was noted through the gastroenterostomy.

The patient has had no return of symptoms since 1924.

CASE XXV. (Dr. J. Douglas.) A. C., male, aged forty-one, was admitted on June 1, 1917. Six hours before admission he had had a sudden sharp severe pain in the epigastrium. He gave a very indefinite history of indigestion for years. Examination showed board-like rigidity of the abdomen particularly in the right upper quadrant. The liver dulness was present.

FIG. 18. Case XXIV, eleven years postoperative. Cap was narrowed. No symptoms for seven years.

Immediate operation revealed a small amount of bile-stained fluid in the peritoneal cavity. On the anterior surface of the stomach just above the pyloric ring in the center of only a moderate amount of induration was a 2 mm. perforation. The perforation was inverted, a posterior gastroenterostomy done and the peritoneal cavity drained.

Convalescence was uneventful and the patient left the hospital on June 18, 1917, without symptoms.

Postoperative roentgen ray examination on November 21, 1918, showed that the stomach emptied in six hours through the gastroenterostomy. The duodenal cap did not fill.

He has no return of symptoms up to the present time.

CASE XXVI. (Dr. N. Green.) G. K., male, aged sixty-two, was admitted on July 9, 1919. Twelve hours before admission he had had a violent sudden pain in the epigastrium. For

four years he had had epigastric pain four hours after meals. Examination showed board-like rigidity of the abdomen with obliteration of the liver dulness.

Immediate operation revealed a large amount of dark brown fluid and some gas in the peritoneal cavity. On the anterior gastric wall near the pylorus was a perforation surrounded by a large area of induration. The perforation was inverted and a posterior gastroenterostomy done.

Convalescence was complicated by a separation of the wound. A resuture was done on September 11, 1919, and on September 22, 1919, the patient was discharged without any symptoms.

He returned on January 17, 1923, with a papilloma of the bladder and diabetes, but no gastric symptoms. On March 1, 1923, he returned again, this time with carcinoma of the bladder, diabetes and diverticulitis of the sigmoid, but no gastric symptoms.

Postoperative roentgen ray examination on March 5, 1923, showed the stomach emptying rapidly through the gastroenterostomy. The duodenal cap did not fill.

He had no return of gastric symptoms up to the time when last seen on March 14, 1923.

REOPERATED—GASTROENTEROSTOMY

Case xxvii. (Dr. F. W. Solley.) L. W., male, aged twenty-eight, was admitted on August 11, 1928, because of a sudden sharp pain in the epigastrium two hours before admission. He had had indigestion for three days. Examination showed board-like rigidity of the abdomen.

Operation revealed a 3 mm. perforation on the superior aspect of the first portion of the duodenum in the center of a large area of induration. The abdominal cavity contained a large amount of gastric contents. The perforation was inverted and the abdomen closed without drainage.

Convalescence was uneventful. The patient was discharged August 27, 1928, without symptoms.

He remained well until May 1930, when he began to have slight attacks of pain in the epigastrium radiating to the back. This pain was relieved by food, hot water or milk of magnesia for periods of two to three hours after which it returned. This continued to October 7, 1930, when he reentered the hospital.

On November 10, 1930 (Fig. 19), roentgen ray examination, postoperative to the inversion of the perforation, revealed a large stomach,

Fig. 19. Case xxvii, two years and three months after simple inversion of perforation in first part of duodenum. Active symptoms for six months preceding this picture. Constant deformity of cap and hyperperistalsis show. Gastroenterostomy gave complete relief from symptoms.

normal in appearance with deep hyperactive peristalsis. The cap filled but showed a constant deformity. There was no six hour retention.

On November 11, 1930, operation revealed a thickened area in the duodenal wall at the old site of the perforation. Evidence of the old suturing could be seen. A second indurated area was felt posterior to this and thought to be a second ulcer. A posterior no-loop gastroenterostomy was done.

Convalescence was uneventful and the patient has had no return of symptoms up to the present time.

Case xxviii. (Dr. M. K. Smith.) R. M., male, aged forty-eight, was admitted August 19, 1928. Thirty-six hours previously he had had a sudden severe sharp pain in the epigastrium. He was nauseated but did not vomit. For two years he had been under a physician's

care for gastric ulcer. Examination showed board-like rigidity of the abdomen with obliteration of the liver dulness.

Roentgen ray examination on June 13, 1929, (Fig. 20), showed evidence of an old ulcer with pain on pressure over the site of the deformity.

Fig. 20. Case xxviii, ten months postoperative to simple inversion of perforation just above pylorus. Active symptoms were present for six months preceding this picture. Constant deformity about pylorus and evidences of adhesions to second part of duodenum showed. Gastroenterostomy gave complete relief from symptoms.

Fig. 21. Case xxviii, twenty-one months postoperative to posterior gastroenterostomy for recurrence of symptoms with complete relief.

Immediate operation revealed a walled-off abscess between the stomach, liver and omentum which contained considerable yellow purulent fluid. Just above the pylorus was a 3 mm. perforation and about it a moderate amount of induration, which was inverted and covered with a tab of omentum. A small bleeding area on the liver was packed with iodoform gauze and a rubber dam drain inserted into the peritoneal cavity.

The wound separated down to the fascia, but healed well by granulation. The patient was discharged without symptoms on September 18, 1928.

The report and films of a roentgen ray examination on November 15, 1928, were lost. The examination had been made because of a return of mild ulcer symptoms.

He was readmitted June 11, 1929, because of epigastric pain with occasional nausea and vomiting of six months' duration. Milk or soda relieved the pain.

There were evidences of adhesions to the second portion of the duodenum but the stomach was empty at six hours.

Operation on June 15, 1929, revealed the pylorus and first portion of the duodenum firmly adherent to the under surface of the liver. From inside the stomach the old ulcer could be felt but the adhesions were not disturbed. A posterior gastroenterostomy was done.

Convalescence was uneventful. The patient was discharged on July 1, 1929, free of all symptoms.

Postoperative roentgen ray examination on March 11, 1931, (Fig. 21) showed a stomach that filled well and emptied rapidly through the gastroenterostomy. The bulb showed constant irregularity and the remainder of the duodenum was not visualized.

He has had no return of symptoms to the present time.

Case xxix. (Dr. E. J. Donovan.) J. J. S., male, aged forty-five, was admitted on April 22, 1929, because of tarry stools. He had had continuous epigastric pain for periods of

several weeks at intervals during the year preceding admission. This pain had no relation to meals. Examination showed a very tender epigastrium with no obliteration of liver dulness.

Fig. 22. Preoperative roentgenogram of Case xxix shows an irregularity of first part of duodenum which was constant. Operation revealed a sealed off recent perforation at this site although a temporary duodenal fistula formed postoperative. No symptoms since operation.

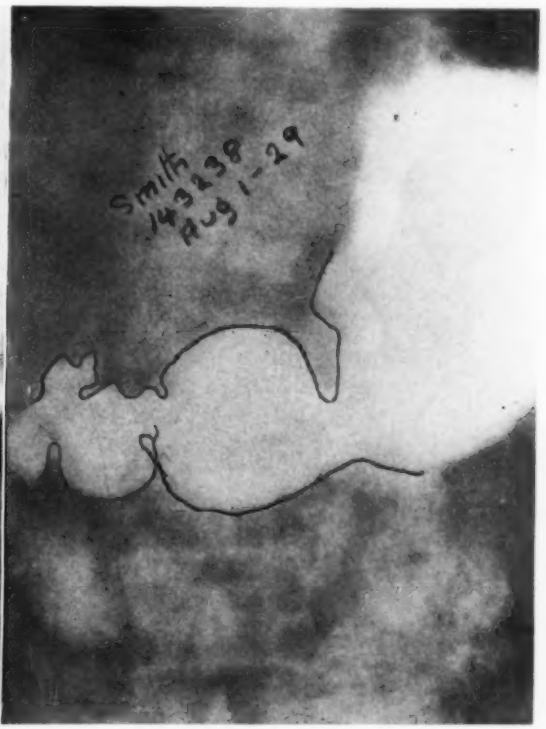

Fig. 23. Case xxix, three months postoperative to simple inversion of perforation in first part of duodenum. Irregularity in cap was constant. No symptoms since operation.

Roentgen ray examination April 25, 1929 (Fig. 22), revealed a large stomach with a sensitive pylorus. The duodenum was small and irregular. There was no six hour residue.

Operation on May 1, 1929, found a perforation of the first portion of the duodenum with an area of localized peritonitis. The ulcer was inverted and a rubber dam drain inserted into the peritoneal cavity.

Convalescence was stormy. Two transfusions were given. A temporary duodenal fistula formed but closed spontaneously. The patient was discharged June 15, 1929, free of all symptoms.

Postoperative x-ray examination August 1, 1929 (Fig. 23), showed a spastic stomach with spasticity and irregularity of the pylorus and first portion of the duodenum.

In the first sixteen months postoperative, his weight increased from 90 lb. to 140 lb. He returned to the hospital on October 19, 1930, because of a sudden severe epigastric pain three days before admission. This had decreased in severity gradually to the time of admission.

Postoperative x-ray examination on October 20, 1930, (Fig. 24), showed a small active stomach, high in position. The cap filled but was irregular. No spasm or tenderness was noted and there was no six hour retention.

Operation on October 25, 1930, revealed the viscera of the upper abdomen covered with adhesions. The region of the ulcer was not visualized or palpated. A posterior no-loop gastroenterostomy was done.

On November 5, 1930, he began to vomit. On the next day he had a definite intestinal obstruction and a jejunostomy was done and the obstructed mass short circuited by a jejunoileostomy. Convalescence was uneventful. The patient left the hospital on December 2, 1930, without symptoms and has had none to the present time.

Case xxx. (Dr. R. W. Bolling.) C. A., male, aged twenty-six, was admitted on

December 3, 1926. Nineteen months previously he had had a perforated ulcer of the first portion of the duodenum which was

Fig. 24. Case xxix, eighteen months postoperative. Cap was constantly irregular. Symptoms for three days only before this picture. Gastroenterostomy done with complete relief.

inverted. The peritoneal cavity had been drained. Since the operation he had been unable to eat solid food because of the great epigastric distress it caused. He had had indigestion and epigastric pain not related to meals for ten years.

Roentgen ray examination on December 7, 1926, (nineteen months postoperative) showed a constant incomplete filling defect of the duodenal cap. This had the appearance of active ulceration. The last part of the antrum also showed considerable deformity, due to spasm rather than ulceration. There was no six hour residue in the stomach but a small area in the cap retained barium which was probably the crater of the ulcer.

Operation on December 13, 1926, revealed adhesions over the duodenum with bands to the liver and gall bladder. The appendix was not found. The duodenum was not explored. A posterior gastroenterostomy was done.

Convalescence was uneventful and the patient was discharged on December 31, 1926, without symptoms.

Fig. 25. Case xxx, five years and seven months postoperative to simple inversion of perforation in first part of duodenum and four years postoperative to posterior gastroenterostomy for recurrence of symptoms. Irregularity of cap was not constant. No symptoms since last operation.

On January 26, 1927, he returned for a right indirect inguinal herniorrhaphy. He had no gastric symptoms. In 1928 he had slight indigestion relieved by correction of diet.

Postoperative roentgen ray examination on June 22, 1928, showed good emptying through the gastroenterostomy. There was no definite defect of the pylorus or duodenum.

Another on December 12, 1930 (Fig. 25), showed active function of the gastroenterostomy, with some emptying through the pylorus. There was a markedly deformed cap but no spasm or tenderness. This appeared to be a healed process.

He has had no return of symptoms to the present time.

REOPERATED—SECOND PERFORATION

Case xxxi. (Drs. F. S. Mathews and A. E. Ada.) L. G., male, aged thirty-six, was admitted on January 28, 1928, because of a sudden severe sharp epigastric pain nine hours before admission. He had had epigastric distress two to

three hours after meals for the preceding three years. Examination showed board-like rigidity of the abdomen.

Fig. 26. Case xxxi, two years and two months postoperative to simple inversion of perforation just beyond pyloric ring, and five months postoperative to simple inversion for reperforation at same site. Perfectly normal stomach and cap showed. No symptoms since second operation.

Fig. 27. Case xxxiii, eleven years after perforation of first part of duodenum was cauterized and inverted and a posterior gastroenterostomy done; four years and four months postoperative to excision of marginal ulcer, undoing of gastroenterostomy and pyloroplasty. Cap was large and constantly deformed. No symptoms since last operation except mild attacks of epigastric distress relieved by soda.

Immediate operation revealed a "punched-out" perforation surrounded by a moderate amount of induration 1 cm. beyond the pyloric ring on the posterior wall of the duodenum. The abdomen and pelvis were filled with a watery fluid. The perforation was inverted and the abdomen closed without drainage.

Convalescence was uneventful. The patient was discharged without symptoms on February 17, 1928, on a Lenhartz diet.

He had no symptoms for eighteen months when he again began to have epigastric distress two to four hours after meals. On December 21, 1929, he was readmitted because of a severe cramp-like pain in the upper abdomen three hours before admission followed by vomiting. Examination showed board-like rigidity of the abdomen.

Immediate operation revealed a large amount of turbid viscid fluid in the abdominal cavity. At the site of the original perforation was a 5 mm. perforation in the center of an indurated area 4 cm. in diameter. There were many adhesions about the duodenum. The perforation was inverted and the abdomen closed without drainage.

The wound opened up, but with no duodenal drainage. It healed well by granulations and the patient was discharged without symptoms on January 30, 1930.

Postoperative roentgen ray examination on May 23, (Fig. 26), showed a small high placed stomach. A large cap filled smoothly and at six hours there was no retention.

He has had no return of symptoms to the present time.

Case xxxii. (Drs. E. J. Donovan and R. W. Bolling.) G. B., male, aged forty-five, was admitted on April 1, 1925, because of a sudden sharp severe pain in the epigastrium one hour before admission. There was no vomiting or previous history of indigestion. Examination showed moderate rigidity and tenderness in

the epigastrium with complete obliteration of the liver dulness.

Immediate operation revealed an indurated area 2 cm. in diameter on the anterior surface of the second portion of the duodenum in the center of which was a 2 mm. perforation. There was a small amount of bile-stained fluid and a considerable amount of gas in the peritoneal cavity. The perforation was inverted and the abdomen closed without drainage.

Convalescence was complicated by bronchopneumonia and pleurisy with a small amount of effusion in the right chest. The upper angle of the wound was infected and healed by granulation. The patient was discharged free from sypmtoms on May 10, 1925.

Postoperative x-ray examination October 16, 1925, showed the stomach held up by the transverse colon which was caught in the hernia. The duodenum and the stomach were distended but at six hours there was only slight residue.

He continued symptom-free until April 22, 1926, when he began to have epigastric distress. On April 23, 1926, he was readmitted because of a sudden severe epigastric pain two hours before admission. He had not vomited. Examination showed a hernia in the upper end of the old scar with marked tenderness and rigidity over the entire abdomen.

Immediate operation revealed at the site of the original perforation a 6 mm. perforation in the center of a moderate amount of induration. The abdomen contained only a small amount of fluid. There were many adhesions between the duodenum, the omentum and the abdominal scar. The old scar and hernia were excised, the adhesions freed, and the perforation inverted. Drains were inserted down to the fascia.

Convalescence was uneventful and the patient was discharged symptom-free on May 10, 1926.

Postoperative roentgen ray examination on November 19, 1926, showed a slightly irregular cap. The stomach was hyperactive and contained no six hour residue.

He remained symptom-free to April 1927, since which time he has not been seen.

REOPERATED—MARGINAL ULCER

Case XXXIII. (Dr. F. S. Mathews.) B. B., male, aged thirty-eight, was admitted on August 28, 1919. He had had epigastric pain three to four hours after meals for the preceding fifteen years. Blood had been noticed in the stools eight to ten years before admission. Two months before admission he had had a sudden severe attack of epigastric pain requiring morphine for relief. Examination showed some rigidity and tenderness to pressure in the epigastrium.

Roentgen ray examination on August 29, 1919, showed the stomach dilated. There was a persistent deformity and non-filling of the pyloric end of the stomach and first portion of the duodenum. At the end of six hours there was moderate retention.

Operation on September 2, 1919, revealed firm adhesions between the anterior surface of the duodenum and the under surface of the liver. In the center of these adhesions was an abscess cavity communicating with the first portion of the duodenum by a 6 mm. perforation in the center of an old indurated ulcer. This opening was 3 cm. below the pyloric vein. The ulcer was cauterized and inverted. A posterior gastroenterostomy and an appendectomy were then done.

Convalescence was uneventful. The patient was discharged free from symptoms, on September 17, 1919.

Postoperative roentgen ray examination on September 16, 1919, showed a stomach normal in size. The meal passed slowly through the gastroenterostomy opening. It was empty in five hours.

Another postoperative roentgen ray examination was made on May 6, 1921, because of recurring attacks of dull aching pain in the left upper abdomen which was relieved by food. No filling defect was noted in the stomach. The first portion of the duodenum filled incompletely. There was marked delay in the second portion of the duodenum and no mention was made of the gastroenterostomy opening.

The symptoms continued as described to June 21, 1926, when he was readmitted to the hospital.

Roentgen ray examination on June 23, 1926, showed an irregularity of the stomach at the gastroenterostomy stoma. The stomach emptied very slowly through the stoma. These findings were very suggestive of a gastrojejunal ulcer.

Operation on June 26, 1926, revealed the old ulcer well healed with some constriction at the pylorus. There was a fairly large marginal

ulcer. The gastroenterostomy was undone, the ulcer excised and a pyloroplasty performed.

Convalescence was again uneventful. During the four years since he has had attacks of mid-epigastric pain relieved by soda at intervals of about six months.

Postoperative roentgen ray examination on October 7, 1930 (Fig. 27) showed a stomach normal in size and placed high. The cap was large and contained a persistent deformity. There was no spasm or retention. This was not the picture of active ulceration.

He has since been controlled by a hyperacidity diet but is troubled by mucous colitis. This is the only diagnosed marginal ulcer in the series.

Note. The 82 patients included in this report were operated upon by the various members of the surgical staff of St. Luke's Hospital. It is with their kind permission that they are reported and I wish to take this opportunity of thanking them for their kindness in permitting me to use their cases.

I also wish to express my thanks for the fullest cooperation afforded me by the Follow-up and Roentgen-ray Departments of the hospital force, and to Dr. Eric Ryan, the roentgenologist at St. Luke's Hospital, for the large amount of work involved in checking these cases from a roentgenological point of view.

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[For Remainder of References see p. 320.]

A STUDY OF

BLEEDING GASTRIC AND DUODENAL ULCERS

WITH A PLEA FOR EARLY SURGICAL INTERVENTION*

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IT is a common experience to those engaged in the practice of gastroenterology to see patients who are suffering

Fig. 1. Ulcer of duodenum. Arrow points to erosion into pancreaticoduodenal artery.

from gastric or duodenal ulcer, of a type soon to be described, literally bleeding to death under the very eyes of the surgeon and internist who are engaged in an academic controversy regarding the advisability of surgical intervention. The postmortem examination of these cases reveals the futility of procrastination. There is usually found an extensive ulceration with erosion into a large artery, such as the pancreaticoduodenal, which is the seat of such marked fibrosis as to make spontaneous closure impossible. The following are 2 illustrative cases:

Case 1. B. G., male, fifty-two years of age, was admitted to the Jewish Hospital of Brooklyn, on the medical service of Dr. S. R. Blatteis, on March 24, 1930, suffering from repeated hematemesis of two days' duration. The onset of his illness dated back to about one year previous to the present attack. At that time he complained of weakness and dizziness. During one of these attacks he fainted. About two months before admission he had a spell of persistent nausea and vomited all food ingested. Several weeks later he had a recurrence of these symptoms. About one month prior to admission he vomited bright red blood and became unconscious for a short time. For the past month he had been complaining of belching, acid eructations, constipation and tenesmus with occasional black stools. The past and family history was irrelevant.

On physical examination the patient was found to be well developed and fairly well nourished but exceedingly pale. The heart sounds were very weak. The blood pressure was 66/45; pulse, 90 per minute, regular, but weak; the temperature was slightly elevated. Abdominal examination revealed resistance to palpation in the region of the epigastrium.

On the day after admission, the patient vomited 6 oz. of bright red blood and passed tarry stools. The hemoglobin determination was 50 per cent (Dare) and the red cell count was 3,750,000 per c.mm. He was given a transfusion of 500 c.c. of unmodified blood to which he responded very well. He felt more comfortable and his general condition was improved. A surgical consultation was had at that time and conservative treatment was advised until the cessation of active bleeding. Soon after this, the patient's condition became worse and another blood transfusion was given, followed by a clysis of 1000 c.c. of a 2 per cent glucose solution. He was somewhat improved and another surgical consultation followed. Further conservative treatment was

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again advised. On the following day, the third day after admission, the patient made a rapid decline and died.

Fig. 2. Transverse section of ulcer through eroded pancreaticoduodenal artery showing marked scarring of vessel wall and fibrosis of perivascular tissue in which the artery is embedded. Note the incomplete thrombus formation in lumen of vessel (low power—hematoxylin and eosin).

Case II. I. D., male, aged sixty-four, was admitted to the Jewish Hospital of Brooklyn, on January 13, 1931, on the service of Dr. Rabinowitz, complaining of weakness, pallor, palpitation and shortness of breath. About three years previously, he began to experience constant epigastric pains, which, however, were not related to meals. At that time, *x*-ray studies did not reveal any evidence of gastrointestinal changes. Three weeks before admission he began to complain of extreme weakness even while at rest. This was accompanied by dyspnea on exertion, buzzing in the ears, and occasional dizziness. He also noticed that his skin was becoming very pale. The symptoms were growing progressively worse. For some time he had been observing black stools which he ascribed to certain powders which were prescribed for him.

On physical examination he was found to be well developed and fairly well nourished but extremely pale. His blood pressure was 100/60, pulse, 140 per minute, regular, but weak; temperature ranged from 99.9°F to 100.8°F.

A soft systolic murmur was heard over the entire precordium. A rectal examination revealed the presence of tarry stools. Proctoscopic examination and a barium enema revealed no rectal or colonic pathology. The hematological

study revealed a severe grade of secondary anemia. The hemoglobin on admission was 19 per cent (Dare) and remained at about

condition and he died about three weeks after admission. Each time that he lapsed into a state of shock and also just prior to death, he

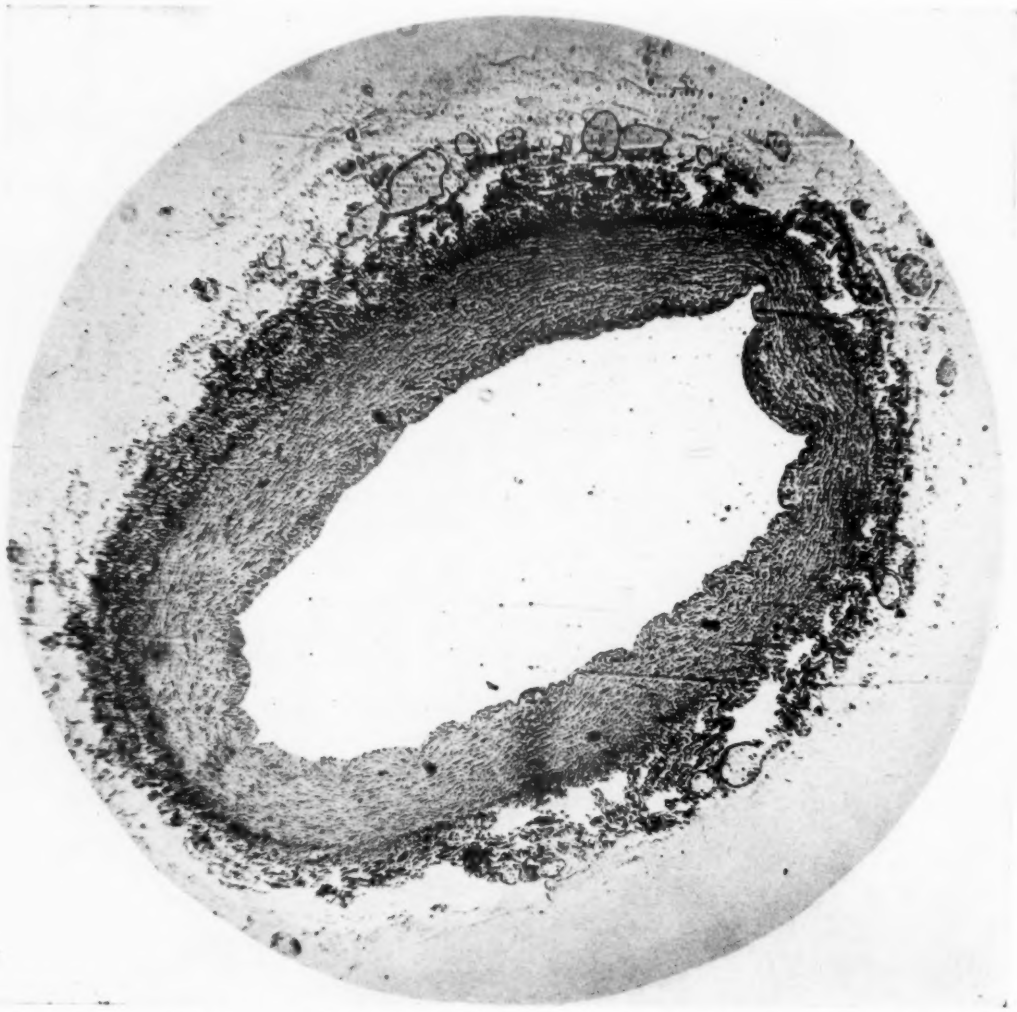

Fig. 2a. Transverse section of a normal pancreaticoduodenal artery of similar caliber as that shown in Fig. 2 and exactly similar location. Note the difference in width of vessel wall as compared to that in Fig. 2.

this level throughout the course of the illness.

As in the previous case, the patient continued to show evidence of massive hemorrhages. There were frequent large, tarry stools. Repeated blood transfusions (a total of about 3000 c.c.) were given, together with liver therapy, in the hope of improving his condition, so as to make him fit for surgical intervention, but without avail. The patient frequently went into a state of shock which was again and again combated by blood transfusion. Although the improvement with transfusion was definite, it was only temporary. Each recurrence left the patient in a more critical

presented the unmistakable picture of air hunger from exsanguination.

POST-MORTEM EXAMINATION

The description of the findings will be limited to the gastrointestinal tract, since the changes in the other systems are irrelevant.

Case 1. *Stomach:* The organ is filled with fresh blood and its mucosa is hypertrophied.

Duodenum (see Fig. 1): The first portion is filled with blood. Just below the pyloric ring there is an ulcer about 4 cm. in diameter and 1 cm. in depth. The margins are smooth and rounded. The base of the ulcer is scarred and a

large bleeding point can be readily demonstrated (see arrow in Fig. 1). The tissue surrounding this bleeding point is the seat of an scar at the base of and surrounding the ulcer. The lumen of the artery is occupied by a thrombus which is firmly adherent to

Fig. 3. Van Gieson stain of Fig. 2, showing fibrous process involving vessel wall (low power).

extravasation of blood. A definite and large erosion into the pancreaticoduodenal artery is found from which a thrombus protrudes. Near the anterior margin of this large ulcer are found two smaller ones which are more superficial and contain no eroded vessels.

Microscopic examination of a section through the ulcer (Figs. 2, 3, and 4) shows destruction of the mucosa and a marked fibrosis of the wall of the duodenum at the base of the ulcer. The fibrosis extends into the underlying pancreatic tissue. The pancreaticoduodenal artery is also the seat of an extensive fibrosis which involves its entire wall, including the intima. The vessel is embedded in the dense the intimal lining and which shows beginning organization.

The rest of the intestines are normal except for the presence of a large quantity of clotted blood.

Case 11. *Stomach* (see Fig. 5): The organ contains a large amount of coffee ground fluid. The wall is thickened and the mucosa is hypertrophied.

Duodenum: A large, punched-out ulcer, about 4 cm. in diameter and 1 cm. deep is found in the portion of the duodenum directly over the head of the pancreas. The edges of the ulcer are undermined and its base is

markedly indurated. There is a large communication between the duodenum and the pancreaticoduodenal artery, so that a probe, erosion presents a most extensive fibrosis of its wall. The elastica of the intimal lining is replaced and destroyed by this fibrous process.

FIG. 4. Van Gieson stain of high power magnification of portion of vessel shown in Fig. 3. Note destruction of elastic fibers by fibrous process. Arrow points to elastic fibers.

the caliber of a matchstick, inserted into the lumen of the proximal cut end of the vessel readily passes into the duodenum. At the site of the erosion the lumen of the vessel is partially occupied by a thrombus which is firmly adherent to the vessel wall (Fig. 6). Two other vessels (veins) which are also eroded stand out prominently in the crater of the ulcer.

Microscopic examination shows a polynuclear cell infiltration in the mucosa and submucosa of the margins of the ulcer. The base of the ulcer is a dense scar which extends to involve the head of the pancreas. The pancreaticoduodenal artery at the site of The perivascular fibrosis blends with the fibrous process in the wall of the vessel, obscuring the outline of the latter. In the interstices of the vessel wall are found many round cells and plasma cells and a few polynuclear leucocytes. The thrombus in the lumen of the artery is undergoing organization, as noted in the previous case.

The rest of the intestines contain a large amount of clotted blood.

DISCUSSION

In reviewing a series of about 75 clinically proved cases of bleeding gastric or

duodenal ulcers, the writers have found that the cases described here represent a distinct group pathologically and present certain characteristic features clinically: The patient is about fifty years of age or over (females, about a decade younger). Although the past history may not be typical of gastric or duodenal ulcer, there is usually sufficient evidence to suggest the presence of one. The symptoms have persisted for nearly a year or more. There have been recurrent hemorrhages, evidenced either in the form of hematemesis or tarry stools. The continued loss of blood results in a severe anemia which, except for the low color-index, may be mistaken for pernicious anemia. With each massive hemorrhage the patient lapses into a state of shock which can be combated only by blood transfusion.

The massiveness of the hemorrhage indicates an erosion into a large vessel and the favorable effect of transfusion probably indicates that the shock is due to exsanguination. There is a persistent decline in the patient's condition and from the very beginning, one can readily appreciate that no improvement can be hoped for unless the bleeding is controlled. From the nature of the pathological changes, it is quite obvious that it is futile to wait for a spontaneous cessation of the bleeding. The artery which is eroded is of extremely large caliber, and since the erosion is along the longitudinal axis of the vessel, the orifice is quite large. The contractility of the vessel is diminished to a minimum due to fibrous replacement of its wall as well as to the dense perivascular scar of the ulcer in which the artery is embedded, so that spontaneous closure cannot possibly occur. In each of the 2 cases described, a thrombus formed in the eroded portion of the vessel, but it was apparently incompetent to withstand the force of the blood stream.

From these findings it is obvious that the only hope for recovery in this type of case lies in surgical intervention to control the bleeding. However, from a review of the current literature and from the opinions expressed in personal communications from various surgeons of wide experience, it is apparent that two difficulties are encountered in the proper management of these cases. One is the difficulty in recognizing any given case as belonging to the group in which the underlying pathology is that of the type of ulcer just described. The other is the poor surgical risk which these patients usually offer for so extensive an operative procedure. As a result, therefore, there seems to be no unanimity of opinion among surgeons as to when intervention is indicated, if at all. Bleeding from peptic ulcers is not always looked upon as a surgical problem. Bevan[1] advises conservative management. Cole[2] is similarly inclined on the grounds that the same constitutional conditions such as arteriosclerosis, which prevents the healing of ulcers, also makes the patient a poor surgical risk. Pfeiffer[3] advised rest, opiates and transfusions.

Fig. 5. Ulcer of duodenum. Arrow points to erosion into pancreaticoduodenal artery.

Many surgeons, however, have realized the need for intervention in bleeding gastric

or duodenal ulcers. Balfour[4] and Blackburne[5] both warn against it during the time of bleeding, but firmly believe that tioned Clendening,[9] Erdmann,[10] Finney,[11] Gowdy,[12] Hartwell,[13] Jordan,[14] Judd,[15] Lahey,[16] Lewisohn,[17] and Mayo.[18]

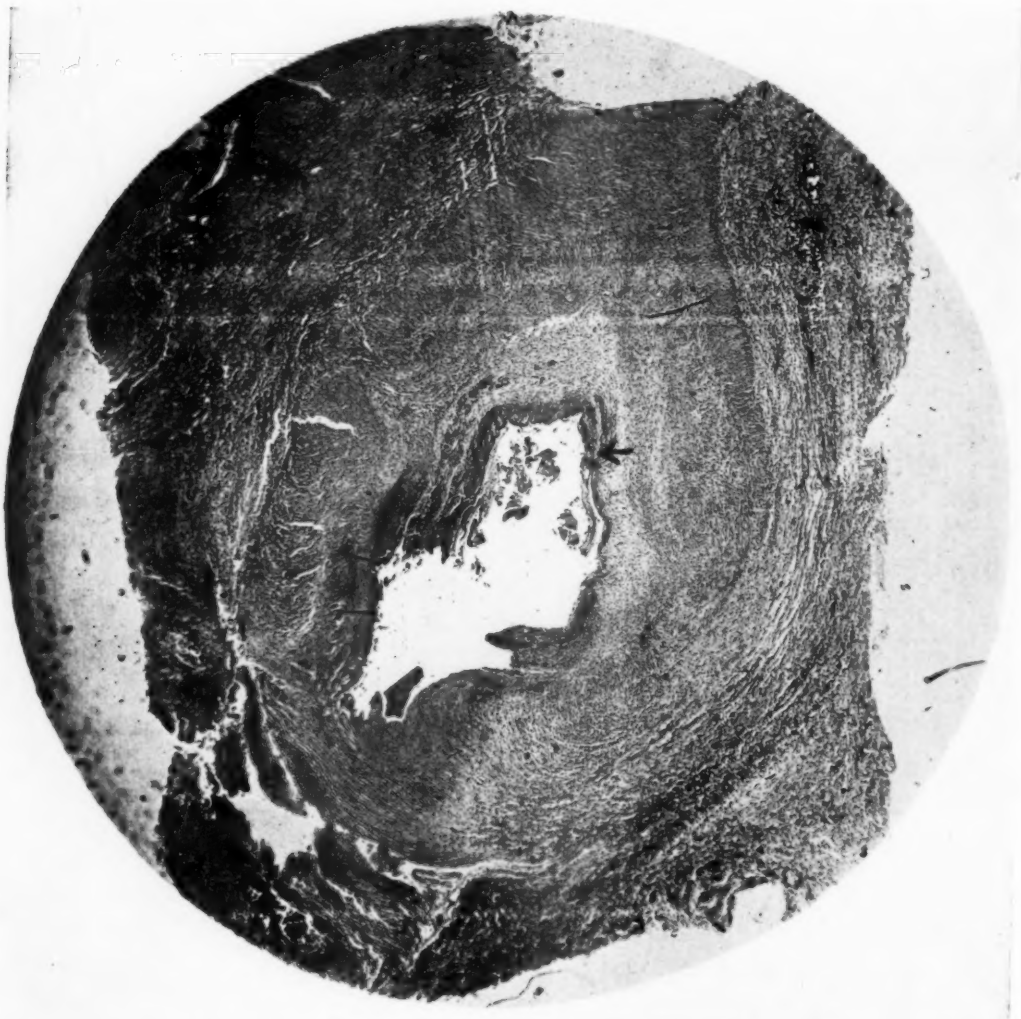

Fig. 6. Transverse section of ulcer through eroded pancreaticoduodenal artery. Note thrombus and fibrous changes identical with those seen in Fig. 2 of previous case. Arrow points to fibrous adhesion of thrombus to vessel wall, (Low power—hematoxylin and eosin.)

hemorrhage is an indication for surgical intervention. Barton[6] ascribes some of the surgical failures in these cases to lack of thoroughness in operating. Blackford[7] advocates resection of the ulcer-bearing area. According to Peco,[8] small, repeated or minimal and continuous hemorrhages, or the constant presence of occult blood, are all indications for surgical intervention, the operation of choice being resection. Among others who consider bleeding an indication for surgical intervention may be men-

It is not the purpose of the writers to discuss the relative merits of medical and surgical treatment of all types of bleeding peptic ulcer, but rather to point out that from a pathological point of view, the type of case described here cannot possibly yield to any but surgical treatment. The bleeding must be controlled, yet the vascular and perivascular scarring preclude the possibility of spontaneous closure of the eroded vessel, and the only other natural possibility, namely, the occlusion of the vessel

by a spontaneously formed thrombus, is ineffective. There can be but one result—fatal exsanguination. It is to this fact which the authors wish to direct the attention of surgeons who fear the high mortality which this type of case yields if subjected to operation. In view of the existing pathological process in these cases, such an attitude on the part of the surgeon is unjustifiable. Certain it is that the mortality in these cases is high with intervention, but it is also just as certain that the mortality in the particular type of case under discussion is much higher if the patients are not treated surgically. No matter how small a number of cases can be benefited by surgery, it is more than other therapy can accomplish, for nothing but surgical intervention can prevent the inevitable exsanguination.

CONCLUSIONS

1. Two cases of bleeding duodenal ulcer are described with postmortem findings. These cases seem to represent a distinct group pathologically and present certain characteristic features clinically.

2. The outstanding pathological process consists of erosion of the ulcer into a large artery (in the 2 cases described here, the pancreaticoduodenal artery) with fibrosis of the vessel wall and perivascular tissue making spontaneous closure of the vessel impossible. The thrombus which forms in the artery is incompetent to withstand the arterial pressure to prevent bleeding.

3. Due to the nature of the underlying pathology, fatal exsanguination may be prevented only by surgical intervention.

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CHOLECYSTOGRAPHY SIMULTANEOUS WITH THE OPAQUE MEAL*

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CHOLECYSTOGRAPHY may be employed simultaneously in conjunction with the barium meal with satisfactory results. As a routine procedure it is inadvisable; for the ingestion of the barium meal will most often result in the non-appearance or obliteration of the gall-bladder shadow. There is however a certain small proportion of atypical deformities of the duodenal bulb which suggests the diagnosis of an ulcer of the duodenum and yet points to extrinsic conditions of neighboring organs, which cannot be visualized by the use of the opaque meal alone. Since Graham and his co-workers have introduced cholecystography we all have come across bulbar defects which were caused by gall-bladder disease. Up to that time roentgenologists very often diagnosed most bulbar deformities as duodenal ulcers irrespective of whether the irregular shape of the filled duodenum was caused by pressure of an extrinsic neighboring organ or by an intrinsic crater of the bulb.[1]

FIG. 1 A. Adhesions between gall bladder and pars descendens duodeni. Note strands of fibers connecting two organs on medial side of gall bladder. There is a distinct impression at lower pole of filled gall bladder. Note angulation of duodenum at place of junction.

FIG. 1 B. A drawing which better illustrates Fig. 1 A because entire duodenum is represented as filled.

Today our diagnosis of duodenal ulcer is more accurate, for we have discovered by the use of cholecystography that many irregularities or deformities of the cap which are seen on the film or screen may be the result of pressure or adhesions of the gall bladder or other neighboring organs.

The following 3 cases will perhaps better illustrate the indications for simultaneous cholecystography in conjunction with the barium meal.

CASE 1. Female, thirty-eight years old, complained of pain in the epigastric region for four years. She suffered from fullness and distress one or two hours after meals; was only

[1] Graham, Cole, Copher, Moore. Diseases of the Gall Bladder. Phila., Lea & Febiger, 1928, pp. 245–251.

* Submitted for publication May 8, 1931.

relieved by the use of alkalies. Roentgenological examination revealed an irregular and deformed duodenal cap. It was extremely tender to pressure. Diagnosis: Duodenal ulcer. Advised operation which the patient refused, but she submitted to a strict dietetic regime and other palliative measures. Her condition however did not improve. It was therefore decided to study the biliary tract for the purpose of excluding gall-bladder disease. Cholecystography showed a normally filled gall bladder and failed to reveal any roentgenological evidence of a definite cholecystitis. There was however an extreme tenderness on pressure in this region. But the function of the gall bladder in reference to filling and emptying itself was normal.

Fig. 2 A. Barium meal three hours p.c., stomach partially filled, apex of cap is indistinct; second segment of duodenum dilated.

Subsequently a compound procedure of cholecystography simultaneous with a barium meal was decided upon for the purpose of determining the origin and cause of the pressure tenderness, for it was obvious that either one or the other of these organs was involved. Examination showed as follows: The stomach was normal in size, shape and contour. The bulb was clearly outlined and visualized. The first segment (pars superior) of the duodenum was more or less deformed at the apex, while the second segment (pars descendens) was visualized and showed band-like shadows running in the direction of the gall bladder. These appeared as small bands and were even more definitely accentuated during screen examination and revealed tender points on pressure. Furthermore special examination by use of

Fig. 2 B. Simultaneous cholecystography and barium meal examination. Cap is cut off, gall bladder filled and clearly visualized, adherent to bulb.

Fig. 2 C. Drawing illustrates relation and mode of attachment of gall bladder and apex of duodenum.

rubber ball compression proved that it was impossible to separate the second segment of the duodenum from the lower pole of the gall bladder. Screen examination definitely showed that if pressure was exerted on the duodenum the gall bladder was drawn towards it. On the other hand if pressure was exerted on the filled gall bladder the duodenum moved in the direction towards it. This explains the symptom complex which appeared in 2 cases. Namely, when the stomach was empty before the examination, the gall bladder was filled with bile and expanded drawing the duodenum towards itself, and giving the patient pain. On the other hand, whenever the stomach was filled the duodenum pulled the gall bladder towards itself giving the patient pain which continued until the stomach more or less emptied itself.

Fig. 3 a. Cholecystography, gall bladder filled, slight constriction near lower pole, bent on itself.

Fig. 3 b. Simultaneous cholecystography, stomach properly filled drawn to right, gall bladder visualized, lower pole indenting cap, visualizing a rounded marginated shadow, calculus.

Fig. 3 c. Drawing more clearly illustrates deformity of cap caused by calculus within gall bladder.

X-ray diagnosis: Adhesions of the gall bladder and the second segment of the duodenum. Operation confirmed the *x*-ray diagnosis (see Fig. 1 a and 1 b, also Figs. 4 and 5).

Case ii. Mrs. A., forty-five years old, complained of gastric pains for two years; she described them as gnawing and at times burning after meals. There was no vomiting of blood or bloody stools. Roentgen examination revealed the stomach normal in size and shape. There were no niches or other irregularities in the contour of the stomach. Tenderness was localized in the duodenum. The bulb appeared irregular in shape and the apex of the triangle was more or less obliterated. There was a decided gas bubble at the junction of the first and second segment of the duodenum. One hour later the bulb appeared dilated and again irregular in shape and the apex of the bulb was

again obliterated. Under screen examination tenderness on pressure was elicited. Tentative diagnosis: Duodenal ulcer. Subsequently a

Fig. 4. Mechanism of drawing gall bladder towards duodenum when pressure is exerted on duodenum under screen examination.

plained of fullness and heaviness after meals, nausea and vomiting. Distress was relieved by vomiting. There was a soreness in the region

Fig. 5. Mechanism of pulling duodenum when pressure is exerted on gall bladder.

compound procedure of cholecystography and barium meal examination was instituted for the purpose of determining the origin and cause of the tenderness in the region of the gall bladder, and particularly to discover the relation of the duodenum and the gall bladder, for while the patient gave a clinical history which pointed towards pathology in the duodenum, no definite roentgenological signs supported the clinical diagnosis. Combined simultaneous examination revealed the stomach normal in size, somewhat drawn to the right. The duodenal cap was quadrangular and the apex appeared to be cut off. The gall bladder was visualized, filled, and clearly outlined. Fluoroscopic examination revealed in this case the similar phenomenon of pain on pressure. The method of compression with the use of the rubber ball failed to separate the gall bladder from the duodenum. The adhesions were practically visualized on the film, for it showed irregular strands of adherent fibers. Further examination by fluoroscope again elicited the phenomenon as described in Case I, namely, pressure on the gall bladder lifted the bulb upwards, while pressure on the bulb pulled the gall bladder downwards (see Figs. 2 A, 2 B, 2 C. Also Figs 4 and 5).

Case III. Mrs. S., aged forty-five years, was sent to me for cholecystography. She complained of fullness and heaviness after meals, nausea and vomiting. Distress was relieved by vomiting. There was a soreness in the region of the liver. Fruits and fats caused distress. There was a definite history of an attack of colic two or three years prior to this examination. Cholecystography showed the gall bladder clearly outlined with a slight constriction near its lower pole. It seemed to be bent on itself. There was no evidence of calculi and the function of the gall bladder was apparently normal, for it filled and emptied itself without any difficulty (Fig. 3 A).

No definite diagnosis was possible. A combined cholecystography and barium meal were therefore instituted to explain the cause of the constriction of the gall bladder and for the purpose of determining its relation to the duodenum. The stomach was properly filled, somewhat drawn to the right. Its contour was normal, there were no niches, diverticula or incisurae. The duodenal bulb was visualized and showed a rounded indentation caused by pressure of the lower pole of the filled gall bladder. This indentation revealed a marginated, rounded calculus, producing the deformity of the duodenal bulb. In this case the simultaneous cholecystography with barium meal examination was the only method which definitely visualized the existence of the calculus (Figs. 3 B and 3 C).

TECHNIQUE

The gall-bladder dye is administered in the usual manner (orally). Twelve, fourteen and sixteen hours after the ingestion of the dye, *x*-ray films are taken until we find a properly filled and visualized gall bladder. If no diagnosis can be reached and the clinical symptoms are indefinite or point to some disturbance in the stomach or duodenum, a barium meal is immediately administered. This process has the advantage that it fills both the gastrointestinal, and the biliary tract at the same time. The simultaneous visual effect renders it easy and convenient to study the relations of the gall bladder to the duodenum. A diagnosis may be reached in this manner in conditions which are difficult to diagnose when barium meal and cholecystography are separate procedures.

DISCUSSION

These 3 cases illustrate some of the more frequent indications for cholecystography simultaneous with the barium meal examination. In Case I, the regular gastrointestinal examination together with the clinical signs and symptoms pointed to an ulcer of the duodenum. But a positive diagnosis of adhesions of the gall bladder and the second segment was only made possible after the simultaneously combined method. Ordinarily the roentgenologist cannot always diagnose a case of adhesion of the second segment (pars descendens) of the duodenum because this part is rarely visualized. Of course it should be noted that while the diagnosis of adhesions is clearly shown by this method of examination, no claim is made that we can determine with this method or any other the nature of the initial lesion which produces the adhesion. Nor can we say with any degree of certainty whether or not the initial lesion which caused the adhesion was in the duodenum or in the gall bladder.

Case II presented similar points of interest with this difference, that the first segment of the duodenum was involved in the adhesion and not the second.

Furthermore the roentgenological and clinical aspect of the case strongly pointed to the location of the lesion in the first part of the duodenum, which was verified by the combined simultaneous examination.

Case III has several points of interest. Clinically the patient gave symptoms of gall-bladder disease. Cholecystography revealed a constriction of the gall bladder near its fundus, but it was impossible to detect any calculus. Indeed the question of biliary calculi never suggested itself until combined cholecystography with barium meal examination was instituted, and this was done for the purpose of explaining the cause of the apparent constriction, and with the least expectation of finding a calculus. The striking feature of this case however is the distinct visualization of the calculus with the combined method, and the failure to visualize it with simple cholecystography.[1,2]

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BILIOBRONCHIAL FISTULA

REPORT OF FIRST RECORDED CASE DEMONSTRATED BY LIPIODOL*

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BY definition, a biliobronchial fistula is a communication between the biliary tract and the bronchial tree which permits bile to ascend into the bronchi.

We report herewith what we believe to be the fifty-third recorded case of biliobronchial fistula not caused by echinococcic or amebic infections and the first recorded case where the fistula has been demonstrated by lipiodol injections. Forty-nine of these cases have been summarized by Morton and Phillips,[1] who also report a case of their own. We have found two additional cases recorded since their paper: one by Seelig and Singer,[2] and one by Meredith.[3]

REPORT OF CASE

CASE I. No. 38,423, white, male, forty-two, laborer, was admitted to the Coal Valley Hospital July 19, 1925, complaining of pain in the right upper abdomen. The history was fairly typical of cholelithiasis. The past history was negative except for an uncomplicated attack of typhoid eighteen years before admission, and recurring attacks of subacute polyarthritis, the last attack two years prior to admission.

Examination showed a tall, fleshy man with face flushed; skin dry, rough, and icteroid; and marked jaundice of the conjunctivae. There was definite tenderness over the right upper quadrant of the abdomen with considerable rigidity. There was also moderate hypertension. Examination was otherwise negative except for irrelevant details.

Laboratory examinations provided the following data: The urine was strongly positive for bile, contained a cloud of albumin and an occasional granular cast. The nonprotein and urea nitrogen were very slightly elevated. Blood sugar was normal; gastric analysis negative, hemoclastic crisis test of Widal slightly positive; urobilin strongly positive; icterus index 33, coagulation and bleeding time normal; and the Wassermann and Meinicke reactions negative.

Roentgenologic examination of the gastrointestinal tract was negative except for an abnormally high position of the duodenum which was interpreted as probably due to adhesions between the duodenum and the gall bladder.

The patient was given a period of preoperative preparation consisting of rest in bed, huge hot wet packs to the liver area, daily hot sitzbaths, and a soft diet, low in fat and protein, high in carbohydrate. Fluids were forced.

Fifteen days after admission he came to operation. The following operative note is copied directly from the patient's record: "Nitrous oxid oxygen plus regional anesthesia. Incision, oblique of Kocher. Stomach normal. The duodenum was normal save for adhesions binding it to the neck of the gall bladder. The liver was considerably enlarged, indurated, edges rounded and boggy, and there was a marked increase in connective tissue trabeculation but no dimpling. The gall bladder was tremendously thickened, filled with calculi, and distended with bile. Fifty cubic centimeters of black, ropy bile were aspirated from the gall bladder; the cystic dust was isolated and a cholecystectomy done. The cystic duct was completely obliterated by scar tissue, therefore, it was impossible to explore the common duct through the cystic duct. The index finger was passed through the foramen of Winslow and the supraduodenal portion of the duct was carefully palpated. No calculi could be felt but the common duct was considerably dilated. The pancreas was enlarged and quite hard. The common duct was incised and thoroughly explored with negative findings. A Horgan tube was placed in the common duct and sutured there. A thickened and adherent appendix was removed; Morrison's pouch was drained, and the abdomen closed in the usual manner."

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The postoperative course was uneventful except that fifteen days after operation the patient accidentally removed the Horgan tube from the common bile duct, following which a small rubber catheter was passed into the drainage tract. Progress continued satisfactorily, and the patient was discharged twenty-seven days after operation, liver function having returned to normal as revealed by a series of functional studies. The jaundice had entirely disappeared. The wound was in satisfactory condition except for a small sinus at the upper angle from which there was a very slight leakage of bile.

The patient was seen again at the end of two months. There had been no jaundice, no clay-colored or tarry stools, or abdominal pain since discharge from the hospital. There had been a moderate amount of flatus but the patient, disregarding dietary instructions, had been eating such foods as fried eggs, fried apples, boiled cabbage, pork, and onions, both raw and cooked, without other discomfort.

Physical examination showed rather marked improvement in the general condition but the small draining sinus at the upper angle of the operative incision was still present. The hypertension had disappeared. Physical findings were otherwise essentially negative.

Laboratory examinations were repeated and the following data obtained: Urinalysis showed a cloud of albumin, pus cells and a few granular casts. Nonprotein and urea nitrogen and blood sugar were within normal limits. Icterus index was 4.8. Urobilin was positive, about two on the basis of four. The hemoclastic crisis test of Widal was negative.

The fact that this patient had so little discomfort following the ingestion of the foods mentioned was regarded as additional evidence that liver function was much improved over its condition at the time of his original admission.

The patient was seen again July 1, 1926, about eleven months following operation. His general condition was satisfactory. There was no flatus, abdominal pain, or food idiosyncrasies but there was some annoying drainage from the sinus at the upper angle of the wound.

At this time the Lahey operation was considered but in view of his generally satisfactory condition and the fact that the discharge was small in amount it was thought best to defer such a procedure until the indication for it became more definite.

The patient did not report to the hospital again until December 31, 1929, three and a half years after the last visit, four years and five months after cholecystectomy. He stated that there had been a continuous discharge from the sinus at the upper angle of his abdominal scar, requiring constant wearing of a thick pad. The discharge was sero-pyoid in character and slightly yellowish in color.

Fourteen days previous to this admission the fistula ceased draining. During the next thirty-six hours a "tingling sensation" gradually developed in the lower right chest, apparently extending upward and centrally from just beneath the incision in the anterior abdominal wall. At the end of this period he began to cough up a sero-pyoid material, greenish-grey in color, at first a small amount, but this gradually increased until the twenty-four hour volume at the time of admission was approximately 500 c.c. Considerable effort was required to raise the sputum, the effort causing intense pain in the lower right chest. The pain disappeared after expectoration of this bile-stained material. Prior to these "fits of coughing" there was usually a sense of suffocation and depression. The frequency of these attacks of coughing was considerably influenced by position, the patient experiencing a choking sensation when lying flat that was usually relieved by coughing up the bile-stained material previously noted. He was unable to lie on the right side because this position caused persistent coughing. The erect and reclining (half-sitting) positions were most comfortable and were accompanied by the least coughing. Stooping did not cause expectoration or precipitate attacks of coughing.

He did not hiccough at any time, a distressing symptom in some of the recorded cases.

It is interesting to note that throughout this long period, during which there was persistent drainage of bile from the fistula, the patient was completely free from jaundice, clay-colored stools, flatus, and unfavorable food reactions in spite of a diet that was far from satisfactory: prima facie evidence that liver function was approximately normal and that an adequate amount of bile was reaching the intestine, notwithstanding the bile loss through the fistula.

Examination at this time showed the skin and mucous membranes normal. The following pertinent positive data were obtained: There

was an area of paravertebral dullness on the right side extending from the level of the spinous process of the ninth thoracic vertebra downward to merge with the liver dulness. About 10 cm. to the right of the eleventh vertebra there was a small area where persistent, fine, bubbling râles were heard. There were no râles elsewhere and the lungs were otherwise negative. The liver dulness extended to the level of the upper margin of the fifth rib at the right midclavicular line. The lower margin of the liver was not palpable. The postoperative scar in the right upper abdomen was firm and satisfactory except that there was a small inverted area near the upper end. Pressure over the scar did not produce pain or cause fluid to escape.

Laboratory examinations provided the following data: Urinalysis showed a cloud of albumin with a few hyaline and granular casts. Icterus index was 6. Nonprotein and urea nitrogen gave high normal values. Wassermann and Meinicke reactions were negative.

Roentgenologic examination of the chest showed the right dome of the diaphragm to be at the upper margin of the fifth rib in the midclavicular line and the upper border of the diaphragm hazy and indistinct.

The following note, five days after admission is taken from the history: "Productive cough continues. The patient is unable to sleep because he is aroused by coughing every thirty to forty-five minutes. Specimens of expectorated material are repeatedly positive for bile. No foreign bodies have been detected in the sputa."

It was believed that elevation of the foot of the bed for a period of one hour three times a day would facilitate drainage and this procedure was attempted but it produced suffocation and had to be discontinued.

An attempt was made to visualize the biliobronchial fistula by injection of iodized oil (through bronchoscope). A series of teleoroentgenograms showed the hazy and irregular right diaphragm already noted. Each of these films showed a definite area of increased density varying from 2 to 3 mms. in width extending from near the hilum into the obliterated right costophrenic angle, the total length of this uninterrupted shadow being 11 cm.

After carefully considering all available clinical and laboratory data it was decided that the high position of the diaphragm on the right was probably due to a subphrenic abscess and was not entirely dependent upon supradiaphragmatic adhesions.

On January 17, 1930, under local anesthetic, a small incision was made at the upper angle of the old wound. The sinus was located and a probe was passed through it for a distance of about 15 cm., the general direction of the probe being dorsocephalad. Every effort was made to preserve the sinus tract so that it would be in satisfactory condition for performing the Lahey operation if this simpler procedure were unsuccessful. As a result of this probing a thick, creamy, pyoid material exuded. A small catheter was passed into the sinus, and with suction 780 c.c. of this material were removed.

The catheter was left in position to establish free spontaneous drainage and to permit irrigation. Normal saline and Dakin's solution were used for frequent irrigations, the return fluid becoming clear in a few days.

A specimen of pus from the abscess was cultured but no growth was obtained. Stained smears showed a very few staphylococci.

On the day following drainage of the abscess 300 c.c. of a 7½ per cent solution of sodium iodide were injected through the catheter at the upper angle of the wound. Immediately after injection the catheter was removed and a roentgenogram made. This showed a globular mass of increased density about 10 cm. in diameter beneath the right diaphragmatic dome. The upper level of this mass was at the lower level of the fifth rib in the parasternal line. The right costophrenic angle was obliterated.

The iodized oil injections were repeated and a teleoroentgenogram taken. This showed the linear sinus previously noted extending from the right hilum into the obliterated costophrenic angle, merging with the area of increased density referred to in the previous paragraph.

The patient's postoperative course was without event. The cough ceased as soon as the subdiaphragmatic abscess was drained. He was discharged February 1, 1930, cured except for the nephritis which was improved.

A letter from him dated July 29, 1930, stated that his general health is good, that there have been no respiratory infections, and that there has been no coughing of bile-stained material since his discharge. The sinus has completely healed and he has returned to work

CONCLUSIONS

In this case it was not possible to drain the common bile duct via the cystic duct (Lobingier) because it was found, at the time of operation, to be completely obliterated, making it necessary to incise the common duct for the purpose of drainage. The premature (accidental) removal of the Horgan tube probably was contributory to the formation of the chronic sinus. When this closed from lack of adequate pressure the resulting subhepatic accumulation of bile, undoubtedly contaminated because of the prolonged presence of an external fistula, acted as a focus for the formation of the subdiaphragmatic abscess. It seems reasonable to recognize the danger of such a complication from any subhepatic accumulation of bile and in rare cases a biliobronchial fistula may be expected to complicate the picture.

It is also worthy of note that this patient with a prolonged external biliary fistula was able comfortably to consume a diet that contained fats, onions, and fried foods of all kinds. This fact accords fully with the finding of normal values obtained from liver function studies, it having been demonstrated by Laird, Brugh and Wilkerson[4] that there is a close parallelism between the values obtained from liver function studies and the clinical condition of the patient with particular reference to his ability to digest fried, fatty, and greasy foods without excessive flatus and those vague digestive disturbances which contribute so much to the discomfort of patients with hepatic dysfunction.

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SURGICAL ENDOTHERMY IN SUPRAPUBIC PROSTATECTOMY*

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IN an analysis of a series of 277 suprapubic prostatectomies, 44 performed in one step and 233 in two steps, the most frequent complications entailed by the disease process and the operative procedure for its cure were as follows: renal insufficiency, renal infection, hemorrhage, epididymo-orchitis, vesical infection, delayed healing of the fistula, and secondary stenosis of the vesical neck.[1] To combat renal insufficiency and infection catheter drainage or cystostomy was employed. Catheter drainage carried with it the risk of epididymo-orchitis. Cystostomy necessitated a blind enucleation of the adenomatous mass at a second stage. For the control of bleeding surgical measures were impossible and reliance was placed upon gauze packing of the prostatic bed. While this usually lessened immediate bleeding it favored secondary hemorrhage. Despite transurethral irrigation and careful removal of the gauze it has been my experience that hemorrhage has occurred all too frequently from one to ten days later, requiring repacking of the prostatic bed. Occasionally the removel of the second packing has been followed subsequently by renewed bleeding. It is my firm conviction that the element of infection plays an important rôle in these secondary hemorrhages and that packing introduced into the prostatic bed and bladder is conducive thereto. It is probably a factor in the other phenomena of infection, namely intense cystitis which may be gangrenous or diphtheritic, and virulent ascending infection of the ureters, pelves and renal parenchyma. It may also be responsible for blockage of the ejaculatory ducts and infection of the epididymes. Blind laceration of

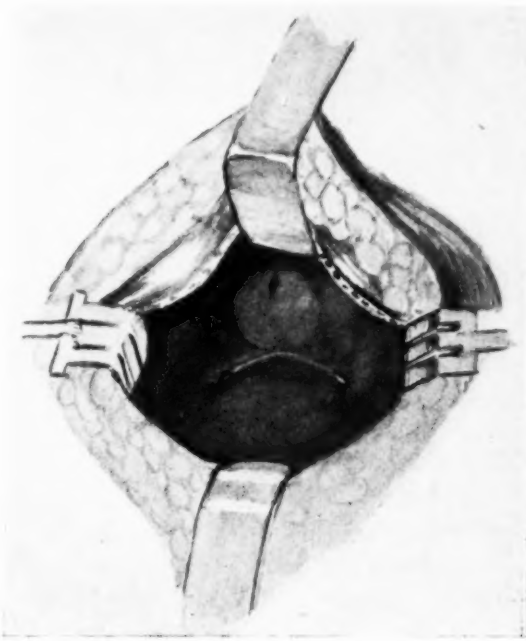

FIG. 1.

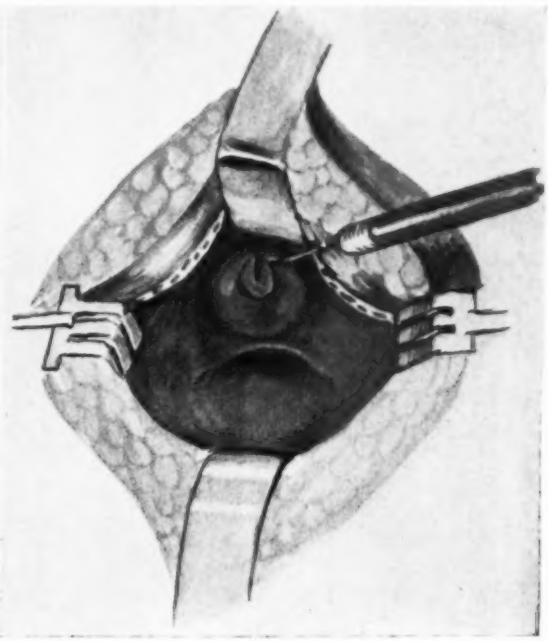

FIG. 2.

[1] Aschner, P. W. *J. Urol.*, 12: 251, 1924.

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the vesical mucosa, the leaving of loose tabs, the failure to properly reconstruct the vesical neck and the fear of passing instruments through the urethra are responsible for the occurrence of late obstructing stenoses, even complete occlusions at the upper end of the prostatic pouch.

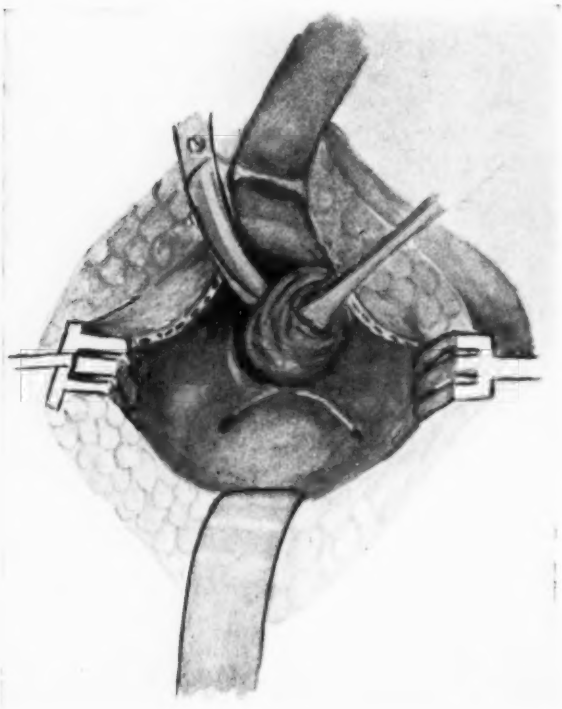

Fig. 3.

To overcome these various complications of the surgery of benign prostatic adenomatous hypertrophy I have gradually developed the following course of procedure. The tentative diagnosis of obstructing hypertrophy having been made by history and physical examination, including the demonstration of residual urine amounting to 120 c.c. or more, the patient is admitted to the hospital. Under local infiltration analgesia, a small incision is made just below either external ring, the spermatic cord delivered, and vas deferens isolated and about half an inch resected between catgut ligatures on both sides. Hemostasis being meticulously assured, the wounds are closed with silk and a small gauze collodion dressing applied. Failure to attend to hemostasis may result in an enormous hematoma of the scrotum.

A soft rubber indwelling catheter is now placed to secure vesical drainage. If there is great retention gradual decompression should be carried out. Bladder irrigation twice daily and changing of the catheter every fourth day after proper urethral irrigation are ordered, There need be no fear of epididymitis, as the vas resection prevents it. The usual functional studies are now made. *X*-ray examination and cystography are carried out in every case to exclude calculus and diverticulum. The cystogram will also indicate the degree of prostatic encroachment upon the bladder neck. Cystoscopy gives further information as to the prostate and bladder, and the intravenous injection of indigo carmine permits observations upon the renal function and ureteral patency. It is inadvisable to catheterize the ureters unless supravesical calculus is suspected. Intravenous urography (Swick's method) will give much knowledge of the state of the kidneys and ureters.

Vesical drainage having been maintained for seven to ten days and there being no functional or pathological contraindications, the sutures are removed from the inguinal wounds and the prostatectomy is proceeded with. Analgesia is obtained either by combination of sacral nerve block (epidural) and abdominal wall infiltration or by low subdural injection of neocaine, 100 mg., or nupercaine 10 mg. My own preference is for neocaine spinal analgesia as the prolonged action of nupercaine is not necessary here. The indifferent (large) electrode of the endotherm apparatus is placed under the buttocks and sacral region.

A 5 inch median hypogastric incision is made, the linea alba is incised and the peritoneum stripped back from the distended bladder. Guy sutures being passed the water is allowed to empty out through the catheter. The bladder is now opened liberally in the midline of its anterior aspect and its interior inspected. This incision may be made with the scalpel or the endotherm knife. The self-retaining Judd Bal-

four retractor is placed. A broad flexible ribbon retractor over a packing holds the posterior wall taut. A narrow ribbon retractor exposes the anterior commissure of the internal urethral orifice, and the catheter is now ordered withdrawn (Fig. 1). With the endotherm needle the anterior commissure is divided and an appropriate incision made through the mucosa overlying the projecting prostate and circumcising the urethral orifice. This incision is carried down to the prostatic capsule (Fig. 2). A tenaculum is applied to the prostate and with gentle traction the mass is enucleated under direct vision using a closed blunt curved scissors as a dissector (Fig. 3). As much of the lower part of the posterior urethra is preserved as is possible; it is cut across with the endotherm knife. By the use of Allis forceps to hold open the vesical mucosa rimming the cavity, bleeding vessels are caught with long artery forceps and immediately sealed by touching the forceps with the endotherm needle (Fig. 4). It is not necessary to change the type of current employed. Tabs of tissue are also readily removed with this cutting needle.

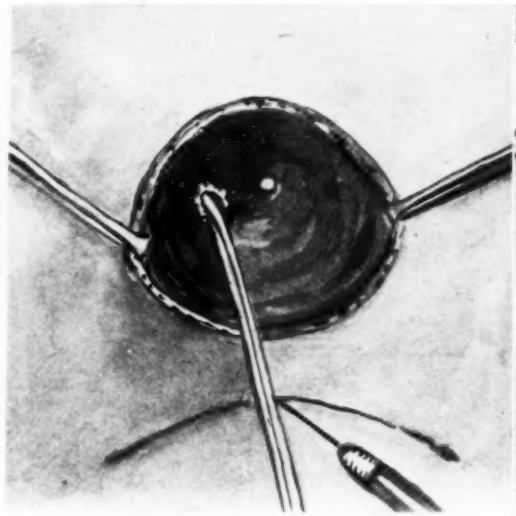

Fig. 4.

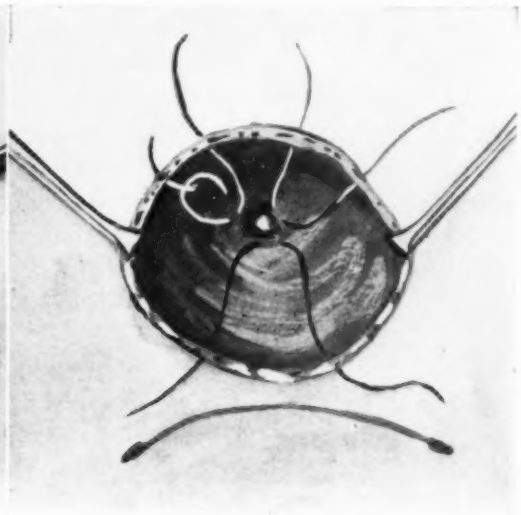

Fig. 5.

Hemostasis being secured in this manner the cut edge of vesical mucosa with its underlying muscularis is sutured down into the prostatic cavity, bringing the mucosa down to that of the urethral stump but not attempting to pass sutures through the latter. The first suture brings down the posterior margin (6 o'clock) using a mattress stitch of zero catgut. One on either side (3 and 9 o'clock) completes the repair converting the prostatic pouch into a funnel wide open above and leading to the

Fig. 6.

urethral stump (Fig. 5). No bag or packing is used. Hunt, Deaver, Thomson-Walker and Lower use ligatures for bleeding vessels in the prostatic bed, but electrocoagulation is much simpler. Hunt inserts a bag for further hemostasis but I see no necessity for this and it may be harmful. Lower approximates the vesical mucosal rim from side to side leaving just room enough for a urethral catheter, but this, I believe, tends to convert the prostatic cavity and bladder into an hourglass form. It is preferable to convert the prostatic cavity into a funnel, wide open above and tapering down to the urethra (Fig. 6.) as is done by Hunt, Deaver and Thomson-Walker.

The bladder is now closed with interrupted plain catgut sutures around a tube 1.5 cm. in diameter led out from the vertex of the bladder. Reinforcing sutures of chromic catgut are then placed approximating the outer layers of the bladder wall. A packing to the space of Retzius, and another to the peritoneal reflection are inserted and the abdominal wall closed about the drains. A week later the tube and packings are removed and a urethral catheter may be inserted as before operation. Irrigation is then used only to maintain free drainage. The wound is found to close completely in from fourteen to twenty-one days. There has been no more bleeding than is frequently seen after simple cystostomy. In one of the earlier cases, not having complete confidence in the procedure as a preventive of bleeding, I placed a packing in the funnel area. This patient was slow in healing and later developed some stenosis. The worst risk was a man of seventy-one with blood urea of 90 mg. and blood sugar of 500 mg. on admission with complete retention.

The procedure is not applicable to those patients in whom indwelling catheter drainage cannot be employed and in whom cystostomy must be resorted to for adequate preparation. The presence of vesical calculi also necessitates the two-stage procedure. In the event that a two-step prostatectomy is necessary packing of the prostatic bed may be frequently dispensed with, and should be avoided whenever possible.

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FRACTURES OF THE SPINE*

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FRACTURES of the spine at best present a difficult problem, if one is to return the patient to full function at his former occupation. Until quite lately, the profession generally seemed to be content with fixation, in spite of deformity. Considerable skepticism existed as to the ability of the vertebral centrum to repair its fractures, with the result that a great many patients having simple uncomplicated crush fractures never returned to their former occupations. The majority of them came into the hands of the extremity surgeon so long after the initial fracture, that spinal fusions were frequently necessary. Results from methods which attained only partial correction, left much to be desired from the standpoint of function. The patient with a fractured spine was indeed to be pitied, because he usually endured a fixed position prohibiting adequate nursing care. This position had to be retained for months, and in the end, the *x*-ray showed varying degrees of deformity. The occasional case that was symptom-free and fully functioning, was either the fused case or the one in which nature had fused the immediate region of the crush, presumably for the usual reason that nature fuses joints elsewhere.

What then may be considered the ideal of treatment and care? First, as nearly perfect anatomical repositioning of fragments and restoration of alinement as obtains in fractures elsewhere in the body. Second, a detailed plan which anticipates from the beginning, all the steps necessary to return the patient to his former occupation. Third, a simplification of method which takes into account the comfort of the patient and permits ready access to all parts of the anatomy for the treatment of associated fractures, pneumonia, and the various complications ordinarily encountered in the treatment of severe fractures. Frequent change of position requires a special splinting apparatus. From the point of view of the best care of an individual fractured spine, treatment should be taken to the place where the man is injured, because of the damage which may occur as a result of transportation for long distances. The method therefore should utilize materials universally available.

MECHANICS OF PRODUCTION OF CRUSH FRACTURES

The anatomical peculiarities of various sections of the spine have a distinct bearing on the nature of the fracture. The cervical vertebrae are broad, shallow, with thick intervertebral discs and large range of motion. The typical fracture in this region is the dislocation with perpendicular fracture through the thickness of the centrum. The thoracic vertebrae are taller, smaller in circumference and their posterior arches overlap each other in shingle-like fashion. In this region the incidence of crush fracture increases. In the lumbar region the main peculiarity is the high anterior vertical diameter and great mobility.

Various authors have shown the great preponderance of crush fractures at the dorsolumbar junction. The incidence in this region is as great as 70 to 80 per cent, (see Fig. 1) so that if one were to elect for treatment, the region of the spine most affected by fracture, it would appear worth while to focus attention upon this region, realizing however, *that no one method can be used for all spinal fractures.* The detailed nature of the fracture depends upon the varying anatomical structure of

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the section of spine involved, so with this point in view, it follows that each case demands individual interpretation of

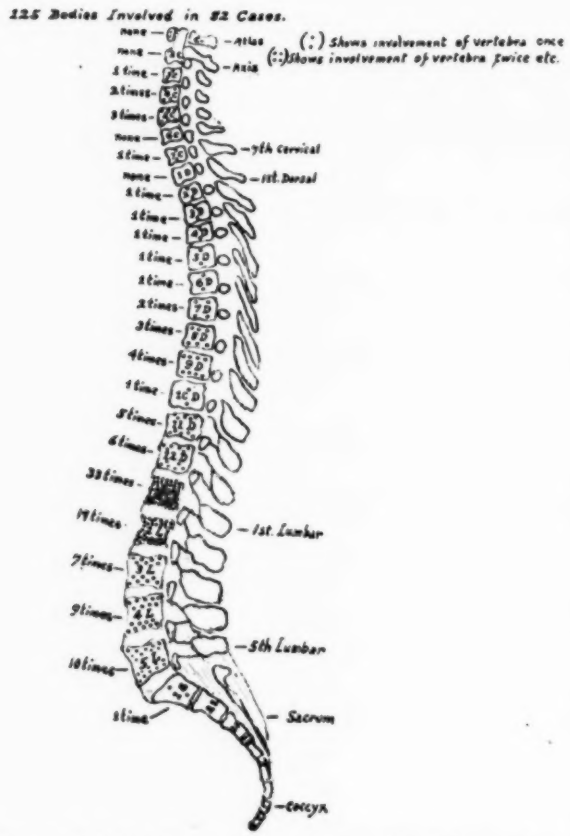

FIG. 1. Relative frequency of fracture involving various individual vertebrae. (Courtesy of Dr. J. O. Wallace, Pittsburgh.)

method. The fact that crush fractures involve principally the dorsolumbar spine and are most frequent in the first lumbar vertebra, points to peculiar structural vulnerability in this region. The chief reasons for this vulnerability may be summed up as follows:

1. The rather common observation that vertical stresses if not dissipated by the resiliency of the well defined thoracic and lumbar curves meet at the junction of these curves which is the region of the tenth dorsal to the second lumbar.

2. The fact that in normal flexion the lumbar spine never moves further than to eliminate its forward convexity to the point of becoming straight or nearly so.

3. The increased anterior vertical thickness of the lumbar vertebrae renders the anterior half of the centra especially vulnerable to vertical force or stresses in flexion.

4. Purely vertical stresses are deflected forward from the dense, highly resistant, lateral masses and posterior arch on to the less resistant spongiosa of the centra. An analysis of the relative cortical bone density demonstrates that the pedicles, articular processes, and posterior aspects of the vertebrae to be much stronger than the cortex of the body. The cortex is thinnest at the midmost portion of the body.

5. Of a more speculative nature but none the less real as affecting the mechanics involved, the following general observations are worth considering:

(a) Most attitudes during work or rest are with the spine flexed in varying degree.

(b) According to the usual history the injuring force is extremely sudden and therefore allows no time for escape.

(c) Danger from in front usually allows sufficient respite to permit escape due to visual warning. Thus with the exception of falls from a height the injuring force usually approaches from above or behind explaining another factor productive of flexion at the moment of impact.

For the problem at hand the torso may be considered as composed of two main levers. An upper, longer, relatively fixed one composed of the dorsal spine and thoracic cage; and a lower, shorter, flexible one, composed of the 5 lumbar vertebrae, loins, and abdomen. The imposed gravital stress of body weight and accidental force, all tend to move this relatively fixed dorsal region *as a mass* forward and downward upon the stronger, more mobile, lumbar spine, which after eliminating its forward curve, "fetches up," resisting further flexion. The forward moving thoracic mass as the upper lever, combined with the extending lumbar spine, places the fulcrum at, roughly,

the first lumbar. The hinge of action of the levers is therefore in the immediate location of the first lumbar. A complete dislocation forward is prevented by the overlapping of the articular processes; nevertheless, a sufficient degree of flexion of these joints occurs to permit a *varying degree* of dislocation forward. Coal mine cave-ins are frequent causes of crush fractures. Two elements usually obtain in the force applied, that is, a vertical and horizontal stress in the shoulder region. The vertical element produces the fracture which, if not a completely impacted crush, breaks off the anterior lip of the centrum, chancing at the moment to be located at the summit of the suddenly produced flex. The junction of the dorsal and lumbar segments combined with the elimination of the lumbar forward curve, then forms at once the summit of the flex and the hinge of the movement.

Wilson,[1] Cotton,[2] Abbott,[3] Wallace,[4] Magnuson[5] Kirchner,[6] Osgood,[7] and various foreign clinics, have pointed to the desirability of hyperextension in the treatment of crush fractures of spine, and various methods were in use, none of which however, aimed at complete reduction of the anterior vertical diameter. In foreign clinics a form of head suspension with the head of the bed elevated and a pillow under the point of fracture, seems quite universal. Bradford frames and plaster shells with felt padding were most commonly used in this country. It would appear that the reason adequate hyperextension has not been done regularly heretofore, was because of fear of consequences. A particular case (Fig. 3) with peculiar distribution of paralysis and great distortion of alinement (jack-knifing) prompted me to hyperextend far beyond what accustomed practice dictated. The fact that this particular patient was not damaged by hyperextension, but, on the contrary, returned to normal in a shorter time than usual, with a complete disappearance of the paralysis and unusual restoration of alinement and vertical height suggested that the same method be used regularly and also prompted on investigation to show reasons why a calamity

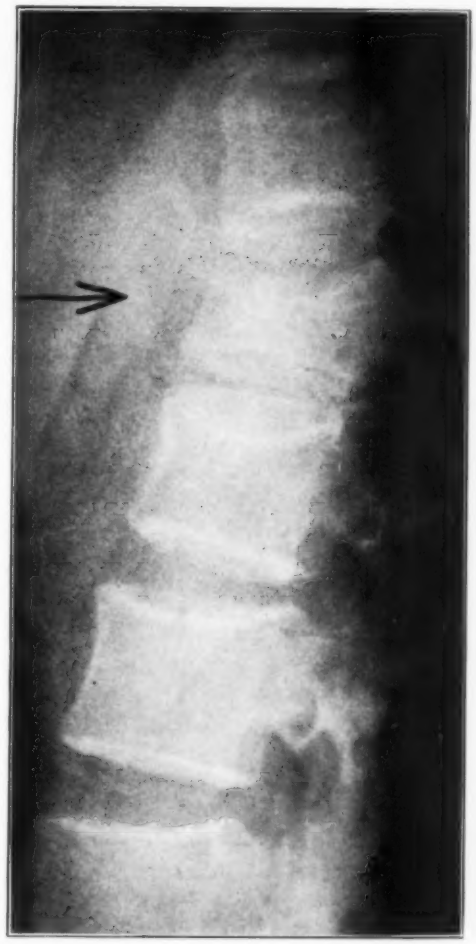

Fig. 2. C. V. B. No. 31828, showing 50 per cent loss of A. V. D.*

did not follow this apparently radical procedure. A detailed study of the lumbar spine and the various structures serving to unite vertebrae, together with the detailed nature of the usual crush, brought out various reasons why adequate hyperextension to the point of actual reduction, can be safely executed.

A prior paper[8] setting forth a method and anatomical interpretations appeared in the *Journal of Bone and Joint Surgery*. Thirty-four cases of fractured spines including 13 crush fracture reductions, were cited in detail. From a reading of this

* A. V. D., abbreviation for anterior vertical diameter.

paper it will be seen that the principles involved in the *reduction* of crush fractures are none other than the general principles

Fig. 2A. Same as Fig. 2. Five and one-half years after, showing restoration of A. V. D. Spine is symptomless, and fully functioning for past five years.

governing the reduction of fractures elsewhere in the anatomy. The method does not depart from the general rule but rather it realizes more fully the application of the general rule to the particular part involved and takes cognizance of the fact that spinal anatomy and physiology require a different method of application of general principles than do the long bones. The fact also that reduction in a crush fracture involves disimpaction calls forth a modification of approach. The paper showed that crushed vertebrae could be completely reduced regularly with complete or almost complete restoration of anterior vertical height. The procedure of reduction and making of shells requires an hour and a half. There was then an average period of seven weeks of shell treatment, followed by an average of six or seven weeks of convalescent, ambulatory treatment with hyperextended

Fig. 3. D. C. No. 35905. First case of manipulative hyperextension. Complete motor, partial sensory paralysis from groins to toes. Complete reduction not attempted. Note projection of posterior superior angle of centrum into canal.

Taylor brace or jacket. Since then the number of crush fractures in my own hands, and in the hands of others, in which this manipulative reduction method was used, has been materially increased. Somewhere between 75 and 100 cases to my knowledge, have been treated by this method, and while there has been no searching analysis made of this group, if one can judge from the reports, complete reductions have been the rule. Return to former occupations has averaged three or four months from the date of accident, materially reducing the convalescence. Only one unhappy result has so far been reported. This is a case of Dr. Clay Murray of New York City, who states

that his patient died within two days after reduction, but according to Dr. Murray's searching analysis and autopsy there was no evidence that the method of reduction was responsible. The final diagnosis was hematomyelia.

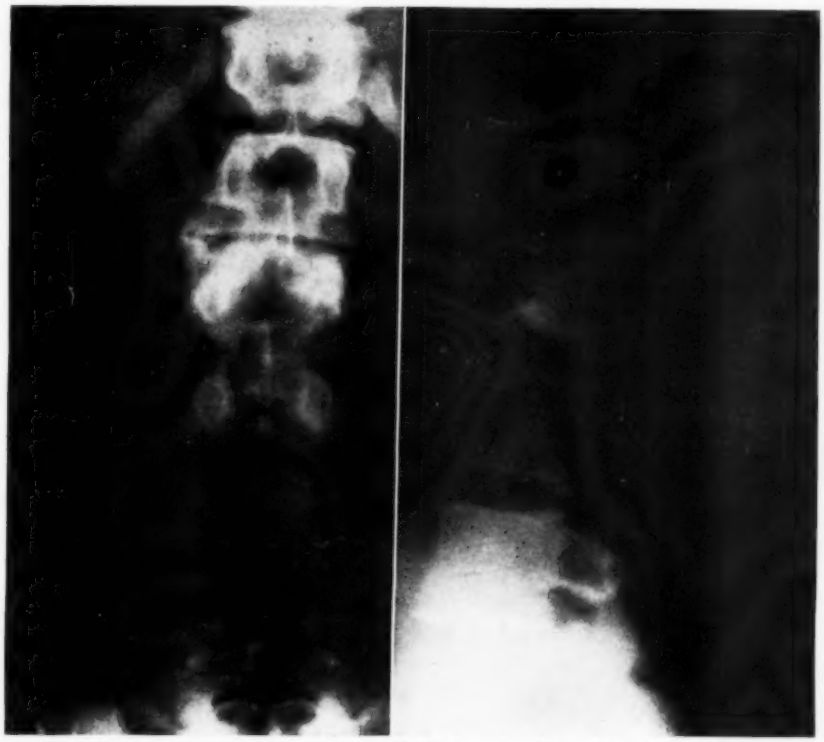

Fig. 3a. Partial restoration of A. V. D. Fair correction of alinement. Spine has been without symptoms and fully functioning for past four years. Note lateral spur.

It seems advisable that where spinal fracture is suspected it is important not to make a general examination that disturbs the position of the patient. After a narcotic the first responsibility is the immediate thorough-going *x*-ray. Very often the first film is not sufficiently detailed and of course it is absolutely necessary to obtain antero-posterior and lateral views. McCutcheon[9] describes an adequate technique. The difference in permeability between the supradiaphragmatic and infradiaphragmatic region must also be allowed for. It may often be necessary to take several lateral views of the dorsolumbar junction to show the necessary detail. I personally supervise the handling of the case at the time of *x*-ray whenever possible in order to minimize the trauma incident to the several transfers usually necessary, by having the stretcher taken directly to the *x*-ray table. *Before moving, a draw sheet is placed around the patient* and the patient is *rolled* rather than lifted or shifted for the necessary position. It seems quite possible that an unparalyzed case may easily become paralyzed through unintelligent handling.

Since the method appeared, there have been a number of questions asking for more details concerning the type of manipulation and whether or not an anesthetic is necessary. The great majority of cases are reduced with anesthetic and without manual manipulation at the point of fracture. Avertin seems the preferable anesthetic, but many cases require no anesthetic. The manual manipulation is reserved for those cases in which the ordinary suspension does not result in complete disappearance of the kyphos. In such cases, several quick but measured downward thrusts are made with thumbs on either side of the spinous process of the

involved vertebra. It is thought that the impaction in this latter type of case is considerably greater than usual and of sufficient strength to render disimpaction impossible by passive hyperextension.

Fig. 4. C. E. No. 41367. Considerable collapse and angulation, coincident chronic arthritis.

Fig. 4A. Fair reduction of A. V. D. Correction of alinement. Fully functioning symptomless spine. Returned to former occupation as carpenter four months following injury.

LATE RESULTS

Grave doubts may be entertained regarding the ability of the collapsed spongiosa to fill in the defect after restoration of contour. Besides, the possibility of a sequel such as Kümmel's disease might well be entertained. The answer to these two questions is that a close followup has been possible in the cases cited and that there has been no experience of this kind to date. All of the patients having crush fractures have returned to their various occupations except one, and here the outcome was befogged by circumstances beyond ordinary control. Moreover, if my impression is correct there is an outstanding difference between a crush fracture treated, from the first, by recumbency and an untreated, overlooked fracture. In the latter case the constant movement of fragments incident to superimposed weight and motion must of necessity compress the body and make for non-union. Six cases are shown herewith (Figs. 2–2A, 3–3A, 4–4A, 5–5A, 6, 7) from one and one-half to six years following crush fracture. With the exception of one arthritic and another in which only partial reduction was obtained, these show no ankylosis, no narrowing of the vertebral substance, and all have fully functioning, symptomless spines. This evidence tends to show that the centrum of a vertebra is surely as capable of forming adequate weight-bearing callus as are other bones. No doubt many normal functional recoveries have occurred with the use of jackets, pure head

and foot traction, the Glisson sling, Bradford frames, waterbeds, plaster shells, ordinary recumbency, etc.; but that this operative and the manipulative reduction method, it seems there is little or no evidence in favor of the former and every-

Fig. 5. G. G. No. 33527. Loss of one-half the A. V. D. with displacement of anterior upper fragment forward and downward.

sort of quasi-treatment is adequate for the average case is at least very questionable. The average case, given this paucity of treatment, yields too large a percentage of sequelae. The aftermath of root symptoms, "lame backs," and progressive bone deformities is largely if not completely, preventable. It is this type of result that requires the internal fixation of a segment of spine to effect a symptomless back.

In reference to the routine or frequent use of fusion operations in fresh crush fractures, it may be worth while to comment. Osgood[7] is frankly against operative interference in fresh crush fractures. Cleary[10] on the other hand is convinced of the value of a fusion operation as a routine, and is commended by several for his attitude. As to the relative merits of the thing to recommend the latter. Since recovery of a fracture depends primarily upon callus formation, there can be no gain in time as a result of operative interference. It seems only logical that bone formation proceeds with the same speed in the case of the fractured centrum as it does in the artificially fractured spinous processes and laminae. While operation accomplishes adequate splintage only after solid fusion takes place, it also confirms the deformity, so that whatever narrowing of vertical thickness, or disalinement exists, is permanently fixed. On the other hand manipulative reduction corrects deformity and disalinement, besides restoring vertical thickness. The shells provide adequate splintage from the beginning. The operative fixation of 5 vertebrae into a solid

piece means a permanent decrease to some extent at least in range of motion of the spine as a whole. The conservative

FIG. 5A. Complete restoration of A. V. D. Anterior upper fragment fairly well restored. This patient returned to construction work four months after accident and has had a fully functioning symptomless spine since then.

method does not compromise spinal motion. It therefore seems that operative fixation is not only unnecessary but also questionable treatment in the great majority of *fresh* crush fractures. Spinal fusion however will probably continue to be necessary in the occasional neglected or inadequately treated case.

FRACTURE DISLOCATIONS WITH PARTIAL OR COMPLETE CORD INVOLVEMENT

No exact line of demarcation can be drawn between the simple crush of a centrum without cord involvement and the other extreme of complete shearing of spine and cord, for which nothing can be done. No rule can be made to differentiate with certainity the case that requires a laminectomy from the one that requires hyperextension only, and the one that requires both. The statistics of many authors including Elsberg's[11] data on 872 cases of various authors are disheartening. The observations of Sharpe,[12,13]

FIG. 6. C. C. No. 72944. Original films not sufficiently clear to show collapse. Case is one of a fireman who returned to work five months after fracture. Figure shows restoration of A. V. D. and of anterior upper corner of centrum. Symptomless, fully functioning spine for past two years.

Taylor,[14] Hartwell,[15] Plaggemeyer,[16] Speed,[17] Mixter,[18] Burrell and Crandon,[19] Hoy,[20] and others offer a wide divergence of views and prescribed treatment.

A preponderance of evidence can usually be adduced for conservative or radical procedure. On the other hand arriving at the proper conclusion for the individual case at hand depends more upon a careful evaluation of the many factors involved. The factors usually the most prominent in determining the method may be classified as follows:

1. The detailed *x*-ray picture.
2. The extent of paralysis, partial, complete, or peculiar, in distribution.
3. The detailed anatomy of the particular section of spine and cord involved.
4. The amount and nature of *x*-ray deformity in relation to the spinal canal and its reducibility or irreducibility by manipulation or laminectomy or both.

5. The probability of transitory edema, contusion, compression, or hopeless transection concerning which conclusions are frequently impossible or at least extremely difficult to arrive at.

6. The time element, urgent in relation to progressive paralysis, hematomyelia, compression, or laceration; equally important as regards postponement of operative means where shock or other formidable complications prohibit.

The impression one gathers from the literature is that laminectomies are frequently done with little thought devoted to reduction of dislocation or deformity, or to adequate splintage afterward: pinning faith upon operation only, while the non-operative measures frequently seem the paramount consideration. The status of the cord being the all important question, is it not as necessary *to restore the spinal canal to its maximum diameter* and normal contour as it is to decompress by laminectomy? Given an immediately successful result with laminectomy what will the final outcome be if spinal deformity is not corrected? Bony compression of the cord is most frequently due to impingement of the sharp posterior superior angle of the centrum. The exact differentiation between edema, contusion, hemorrhage and compression is usually difficult during the first few hours when incision of the posterior commissure is of greatest value. The results of laminectomy per se are universally discouraging. The intensity of the trauma required to produce a fracture dislocation is usually sufficient to produce grave shock and a bad operative risk. Therefore, since these factors frequently obtain, the certainty of manipulative reduction with its accompaniment of restored caliber seems to outweigh or at least should precede operative interference.

On the other hand, the ultra-conservative attitude is equally untenable in view of the experimental work of Allen,[21] who points to the necessity of laminectomy and incision of the commissure within the first five hours, if cord degeneration is to be forestalled. Cases of depressed posterior arch with fracture of laminae and paralysis are certainly an indication

Fig. 7. Another case showing typical restoration of A. V. D. and anterior upper corner fragment. Also symptomless and fully functioning for past one and one-half years.

for operative removal of the compressing fragments. Cases showing definite signs of increasing paralysis along with definite evidence of continuity, would appear to indicate a combination of laminectomy with manipulative reduction, the latter usually preceding the former. So it seems that every paralyzed case should be approached with an open mind as to the necessity of either *operative or manipulative method or both.*

Approaching the problem from another angle, viz., in regard to the reaction of non-medullated cord tissue and grey matter to trauma, Elsberg[22,23] Allen,[24] Frazier,[25] Wilson,[26] Farqhuar Buzzard and Percy Sargent,[27] and Kocher,[28] all point to the relative futility of spinal cord incision and to the absence of nerve regeneration except in the cauda equina.

A number of partially paralyzed cases in my own hands and others, appear to demonstrate that manipulation into hyperextension is an eligible consideration in selected cases of fracture dislocations with

cord involvement. *The most frequent bony pressure is exerted by the posterior superior angle of the centrum.* This type of compression of cord is similar to that of tuberculous impingement or in other words, directly due to jack-knifing. It would be physically impossible to remove such pressure by laminectomy but on the other hand it is rather simple to remove such pressure by hyperextension. The decompressing factor resulting from hyperextension is due to the fact that the spinal canal is restored to its greatest diameter. in any event, with a severe fracture dislocation accompanied by complete or nearly complete paralysis, it appears that hyperextension and adequate splinting should precede laminectomy, because without reduction of deformity, the future function of the patient will be indeed questionable.

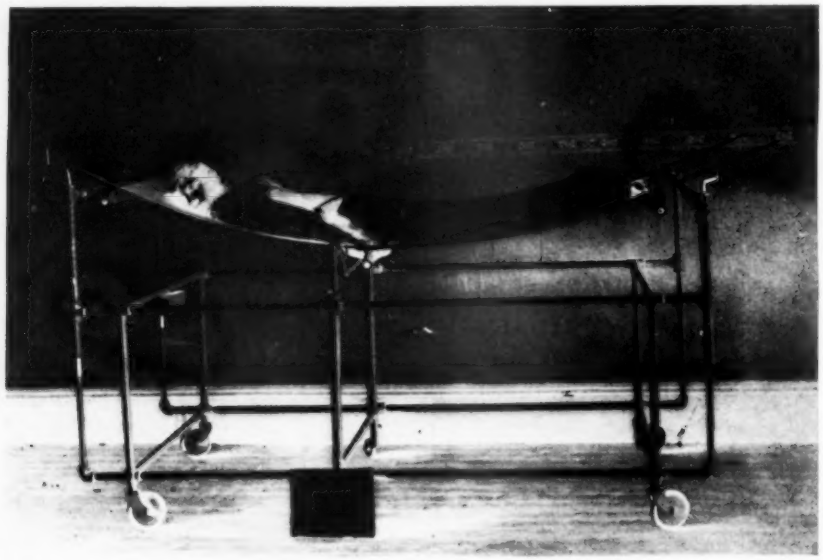

Fig. 8. Modification of Rogers frame. Raised and lowered by gears to permit *prone* or supine hyperextension.

CHOICE OF METHOD

It matters little what method is used so long as complete hyperextension with reduction, as measured by the anterior vertical diameter, is gained. The ingenious method of William Rogers[29] uses a frame to gain immediate or gradual reduction. The method of Dunlop,[30] the method of Wallace,[4] or the simple method of using, in an emergency, a sufficient number of pillows or other materials to obtain and maintain hyperextension, all seem eligible. In the average case of crush fracture, especially the ones with partial paralysis, it would appear to be an advantage to obtain the reduction immediately, thereby converting prolonged bony pressure on the cord to a more transitory contusion from which the cord may recover. In industrial areas, where very severe multiple fractures are common, and internal organ complications are frequent, immediate reduction and splinting in double shells is imperative.

The only serious objection to hyperextension in dorsal decubitus, is in the case of fractured laminae. The gibbus, the apex of which is represented by the tip of the spinous process, must not be made to impinge against a rigid object during reduction. Pressure upon the apex of the gibbus may very easily project a fragment of bone into the spinal canal. Also the fact that fractures of the laminae are difficult of *x*-ray exposition, adds another factor of uncertainty. Such a calamity may be avoided by hyperextension in the prone position, either by the manipulative hyperextension method or with a Rogers frame so constructed

as to produce the necessary degree of hyperextension in the prone position (Fig. 8).

An advantage possessed by manipulative hyperextension is that in the common crush fracture at the dorsolumbar junction, the hyperextension is being practically limited to the lumbar spine. The arc of extension is actually obtained at this point, while in the case of a hyperextensible frame in dorsal decubitus, the pressure of hyperextension is exerted practically as much on the dorsal inflexible spine as it is on the lumbar spine; thus the hockey stick curve described by Lovett as typifying hyperextension, is not as easily produced by a symmetrical arc, as in the case of an arc the lumbar limb of which describes a much sharper curve than the dorsal limb.

SUMMARY

1. Complete reduction of fresh crush fractures is possible when adequate hyperextension and fixation are accomplished early.

2. Several adequate methods of hyperextension are now available, the particular method depending upon the apparatus immediately available, and the special features of the case at hand.

3. Restoration of vertebral contours and spinal alinement are essential to complete restoration of function.

4. The vertebral centrum is capable of forming adequate weight-bearing callus.

5. The double shell and rolling method reduces the labor and increases the safety and comfort of the patient considerably.

6. Convalescence from crush fractures has been materially shortened.

7. Hyperextension and shells are not only applicable but highly desirable in many cases of *fracture dislocation* of the spine with paralysis.

DISCUSSION

Dr. Swift's description of the fractures of laminae and pedicles is extremely interesting. It is not surprising that with the advantage of actually seeing through an incision that these fissure fractures occur. Obviously with the overlapping, intricate, structure of vertebrae, the *x*-ray would not be expected to show such fissures. On the other hand, any considerable displacement of such fractures would be more likely to show, and one wonders whether fissure fractures without displacement need seriously concern us. I want to ask Dr. Swift if he has seen appreciable displacement in these fractures of laminae and pedicles.

It is significant that both Dr. Rogers and myself depend upon the posterior arch to bear the weight during convalescence. Dr. Rogers has gone further in allowing the patients to be ambulatory in extreme hyperextension, at a very early date, in a well-fitting jacket. Perhaps Dr. Rogers' method of early weight bearing is the better, but personally I always had in mind the possibility of the hidden fractures of the posterior arch, mentioned by Dr. Swift. In my own cases, we fit a well hyperextended Taylor brace after about six to seven weeks of shells. The patient is taught how to use it. The brace is applied with the patient prone and the brace altered until adequate hyperextension is obtained. The patient then possesses the advantage of being up and active in about six weeks, and in this way hardens his callus, preventing later collapse.

If it can be demonstrated in a particular case that the laminae are fractured on both sides, such cases would appear to contraindicate any method which exerts pressure against the spinous process. The fact that the laminae are fractured means an unusual traumatizing force, tending to produce hyperextension and not usually associated with crush of the centrum. The removal of such posterior arch may be imperative.

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OSTEOGENESIS IMPERFECTA*

REPORT OF NINE CASES

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NINE cases of osteogenesis imperfecta, sometimes called fragilitas ossium, are here reported, eight of which are

FIG. 1. Osteogenesis imperfecta congenita, Case v. Multiple fractures of long bones in a child three days old.

of patients at the Hospital for Ruptured and Crippled, the ninth being a patient who was admitted to the Orthopedic Service at Bellevue Hospital, and operated upon about one year ago for correction of the marked anterior bowing of the tibiae. This last case is of particular interest and is reported in some detail. All these cases were characterized by an imperfect development of the bones, and the presence of blue sclera.

Osteogenesis imperfecta is a systemic condition of unknown origin, two types of which have been reported. Loebstein described the condition in 1835, pointing out that fractures are often noticed early in infancy or in the first few years of life. In 1849 Vrolik described the type developing in fetal life, these cases frequently being still births or dying shortly after birth. This has been given the name of osteogenesis imperfecta congenita, and is illustrated by Cases v and vi. The bone fragility may persist throughout life, although usually, if these patients live to adult life, the tendency of the bones to fracture decreases as seen in Cases viii and ix.

In the last case presented, no fractures had occurred for ten years, but the marked residual bowing of the long bones, particularly of the tibiae, was striking.

The etiology of osteogenesis imperfecta is unknown. In some of the cases reported there is a familial tendency and Constans reports two cases illustrating this. In one of his cases the mother had blue sclera, deafness, and frequent fractures, while her brother had blue sclera but no history of fractures. In the other case the father and brother had blue sclera and a history of frequent fractures, and the three children of the patient's brother had blue sclera and a history of frequent fractures. In the cases I have seen there has been a rather striking absence of familial or hereditary tendency. Endocrine disturbances have been thought to be a cause but no definite data can be advanced to substantiate this, although several writers are impressed with the possible rôle of the parathyroid as a causative factor. Severe trauma occurring late in pregnancy, amniotic bands and intrauterine adhesions have all been mentioned by various writers as predisposing factors, but as yet definite

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proof is lacking. Syphilis definitely does not seem to be a factor.

While opinions differ as to the method of abnormal formation, bone fragility is the outstanding feature of the condition. Sigowa states that the pathological process consists in a disproportion of the building-up and the breaking-down activity leading to osteoporosis. Axhausen believes that there is a mal-deficiency of periosteal bone formation on account of the lowered function of the osteoblasts. Whatever the reason, it is obvious that during the active period the bones are delicate in structure and fractures may occur by the patient merely turning over in bed. One parent in this series stated that her childs' bones were "like glass."

The roentgenographic appearance is characterized chiefly by a decrease in the lime salts. The bones become soft, and in part cartilagenous, giving rise easily to multiple fractures or bowing of the long bones involved in weight-bearing. The vertebrae as well become deformed so that the patients are usually of short stature. In the acute stage a roentgenographic examination may disclose multiple fractures which have united with marked callus formation, in spite of the decrease in the calcium salts of the bones. In the cases in which the bone fragility has been arrested, it has been frequently noticed that deafness is a common complication, the explanation being that it is due to an abnormal deposit of calcium salts in the small bones of the ear.

In these older cases the fractures heal slowly with an absence of any marked callus formation, as shown in the case of this series in which an open operation was performed. In these older cases the cortex of the bone is thickened and very hard and the contour of the bone is remarkably altered.

Fig. 2. Osteogenesis imperfecta congenita, Case VI. Malunion of long bones following fractures in a child six months of age.

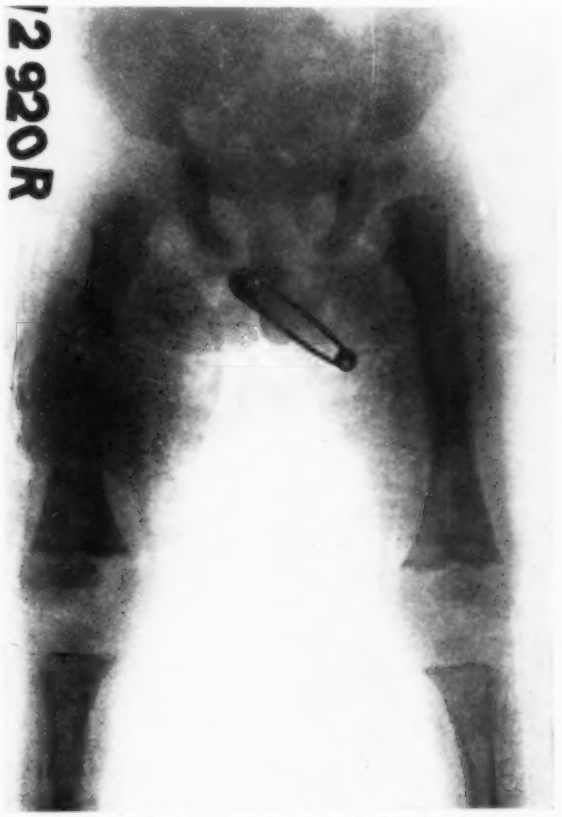

Fig. 3. Marked callus production during healing stage. This is in marked contrast to those cases in which the process is arrested. See figures 5 and 7.

The blue sclera are an essential part in this syndrome. It has been said that not all patients who have blue sclera possess bone

Fig. 4. Marked anterior bowing of right leg in Case ix. Note thickened cortex indicative of process of bone fragility being inactive.

fragility, but that all cases presenting fragility of the bones have blue sclera. This color is thought to be due to a decrease or absence of the quantity or quality of the fibrous tissue, allowing the choroid to show through the thin sclera. In the cases reviewed it was noticed that during early life the sclera were of a characteristic pale china blue, while in the older cases the color was of a distinctly darker blue.

The blood chemistry in these cases has often been studied, and in most of the cases has been found perfectly normal. In only one patient of this series was the blood chemistry carefully studied, and nothing abnormal was noted.

The treatment of osteogenesis imperfecta is naturally one of protection, as no medicine is of any specific value. These patients usually find it necessary to lead very guarded lives and many of them become bedridden and need institutional care. Fortunately with these early cases the fractures heal readily and reduction is usually simple. In the older cases in which the process appears to be arrested attention can be directed to correcting the residual deformities by osteotomy. Healing is usually much delayed in these older cases so that a long period of immobilization is necessary and often braces may be required to protect against subsequent injury.

CASE REPORTS

Case i. F. B., a female child, came to the clinic at the Hospital for Ruptured and Crippled on September 5, 1928, walking with great difficulty. The child was ten years of age, 50" high, markedly overweight, with the characteristic blue sclera, complaining of pain in the hips on walking. The mother stated that the child had had her first fracture of the thigh when four days old, but that the family history was negative for any similar condition. She gave a history of having had sixteen fractures in the lower extremities, and *x*-rays of the long bones of the lower extremities revealed slender deformed shafts, with marked decalcification, with evidence of a number of previous fractures. She came to the clinic on account of a subtrochanteric fracture of several months' duration which appeared to be healing well but with a marked degree of coxa vara. When last heard from the patient was bedridden, receiving institutional care.

Case ii. D. G., a male child sixteen months of age, was brought to the clinic at the Hospital for Ruptured and Crippled February 18, 1929 with a history of having had numerous fractures of the long bones. He was brought to the hospital because the left femur had been fractured twenty-four hours previously, the mother stating that the bones fractured frequently when the baby was being cared for. The child and mother presented blue sclera, but no history of a similar bone fragility could be obtained from any member of the family. Patient was sent to an institution for care and observation.

Case iii. A. S., a female child eight years of age, was brought to the clinic at the Hospital for Ruptured and Crippled on August 26, 1929.

The mother stated that twenty-four hours previously the child had slipped from a chair, fracturing the left thigh. The patient presented

Fig. 5. Following correction of deformity of right leg in Case ix.

marked tenderness and angulation at the point of fracture, and a roentgenogram showed fracture of the upper and middle third of the left femur. Traction was applied and the fracture healed rapidly. The patient presented the characteristic blue sclera and the mother states that the first fracture occurred at nine months of age. Since this time the child has had innumerable fractures. There was no history of a similar condition in the family. The patient was referred after the fracture healed to a convalescent home for care and observation.

Case iv. M. K., a female child, five years of age, entered the clinic at the Hospital for Ruptured and Crippled on July 1924 for opinion regarding deformities of the humeri and femora. The mother stated that at birth the child presented a number of fractures of the long bones of the body. No family history was available and the last examination showed a child of small stature, able to walk but presenting malunion of both humeri and femora from previous fractures, with intensely blue sclera. No recent data on this case are available.

Case v. H. C., a child three days old, was brought to the clinic at the Hospital for Ruptured and Crippled in June, 1930, because of multiple deformities of the long bones. The child presented characteristic blue sclera, marked anterior bowing of the tibiae, and a roentgenogram of the entire body showed multiple fractures with striking secondary deformities due to the softening

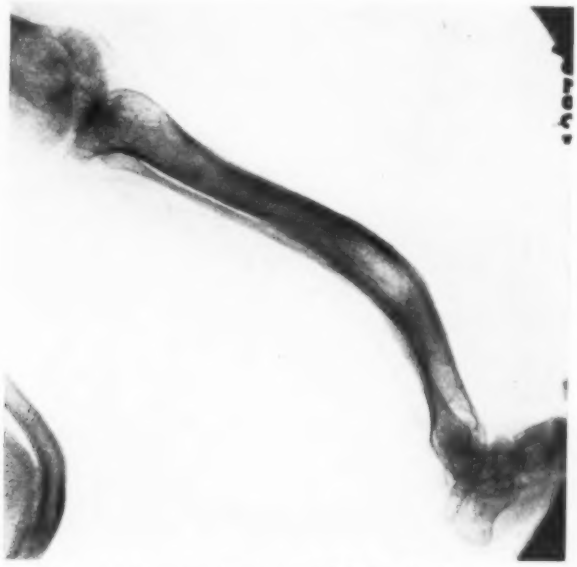

Fig. 6. Anterior bowing of left leg in Case ix.

of the bones. The patient did not return for further observation.

Case vi. J. M., a female child eight months of age, was brought to the clinic at the Hospital for Ruptured and Crippled. There was no family history of a similar condition. This child was the mother's first pregnancy, with normal delivery, and presented marked hydrocephalus with fracture of the femora and humeri, and intensely blue sclera. The patient was referred to an institution for care and observation.

Case vii. A. S., a girl ten years of age, was referred to me on August 15, 1922, on account of a fracture of the upper third of the left femur, caused by falling and striking the left thigh against the pavement. The patient complained of very little pain at the site of fracture and the fracture healed rapidly. The mother stated that the child had had 26 fractures of the various long bones of the body, but that there was no family history of a similar condition. The child presented blue sclera. After the fracture healed the patient returned to her home in Toronto, and I am indebted to her physician, Dr. R. I. Harris, for a recent report on the case. He states that she has had no recent fractures, but presents multiple deformities, and further fractures are prevented only by the patient leading a very guarded life.

Case viii. A. K., a woman twenty-two years of age, returned in answer to a follow-up letter and was seen at the Hospital for Rup-

Fig. 7. Following operation on left leg with correction of anterior bowing. Solid bony union, but note paucity of callus in bone healing, characteristic of these older, arrested cases, Case ix.

tured and Crippled in April, 1924. She walked without assistance, was of small stature, with bowing of the tibiae and femora, and a marked right dorsolumbar scoliosis. She stated that she had had many fractures of the upper and lower extremities, including both clavicles, but that the last fracture had occurred a number of years ago. The patient presented characteristic blue sclera of rather darker blue hue than seen in those cases in which the process was active. She is able to walk about but her deformities interfere with her leading an active life.

Case ix. A. M., a woman twenty-five years of age, came to the University and Bellevue Hospital Medical College clinic on February 24, 1930, on account of deformities of both legs. She stated that within the first year of life she suffered several fractures of her long bones, and during the first ten years of her life had approximately 100 fractures, each occurring very easily so that her bones were thought to be "like glass." For the past ten years patient has suffered no fractures but presents severe deformities as the result of malunion of the long bones. Careful questioning failed to reveal any history of blue sclera or bone fragility in any other member of the family. Patient was 45" tall, presented a short trunk, marked outward bowing of the femora, and anterior bowing of the tibiae. She walked awkwardly but was able to walk unsupported. The upper extremities showed negative symptoms. The sclera of the eyes were remarkably blue but of distinctly darker hue than that noted in the younger cases. A blood chemistry examination was made and both calcium and phosphorus content were within normal limits. The patient was quite deaf and stated that she had noticed increasing deafness which had slowly developed in the last ten years. Both ears appeared to be equally affected. Otoscopic examination was negative.

The patient was admitted to Bellevue Hospital and on September 8, 1930, a wedge osteotomy was done on the left tibia, the fibula being manually fractured. The bone was found very hard, the cortex much thickened, and the shape of the bone remarkably changed. The lateral diameter measured about ½ inch at its thickest portion, and tapered to about ⅛ inch at its thinnest portion. There was a moderate amount of bleeding from the bone. The wound was closed without drain and a plaster bandage applied from the toes to the groin, with the anterior bowing well corrected. On November 28, 1930, a similar osteotomy was done on the right side with similar findings. This healed without any excess callus, as shown in Figures 5 to 7. Union occurred slowly and support was continued for four months, at the end of which time the patient was allowed to begin weight-bearing. At present she is walking about without any support and with the anterior bowing corrected to the degree shown in the recent roentgenograms.

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IMPROVED BONE CLAMP*

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IN open reduction of fractures our most difficult problem has been the retention of bone fragments in proper alignment while fixation is made by plates, screws, grafts, etc., and this through the fact that the bone clamps devised lack in one or more features complete adaptability to this work.

One familiar with this work realizes how frequently his bone clamps will not be adjustable to the fracture involved or will not hold the fracture in proper alignment, or perhaps after adjustment and alignment the instrument is so cumbersome as to be obstructive in placing the plate or graft.

To overcome these difficulties the following instrument has been devised, and by the aid of the accompanying plates, it will be readily seen that the technique of open reduction has been facilitated.

The clamp consists of a pair of jaws adjustable to a lock handle forceps and a universal joint so that after being applied, the handle can be pushed over to either side out of the way of the operator while he places his bone plate or graft. The jaws are high enough so that in deep-seated fractures the handle is permitted to rest out of the way, which is a distinct advantage.

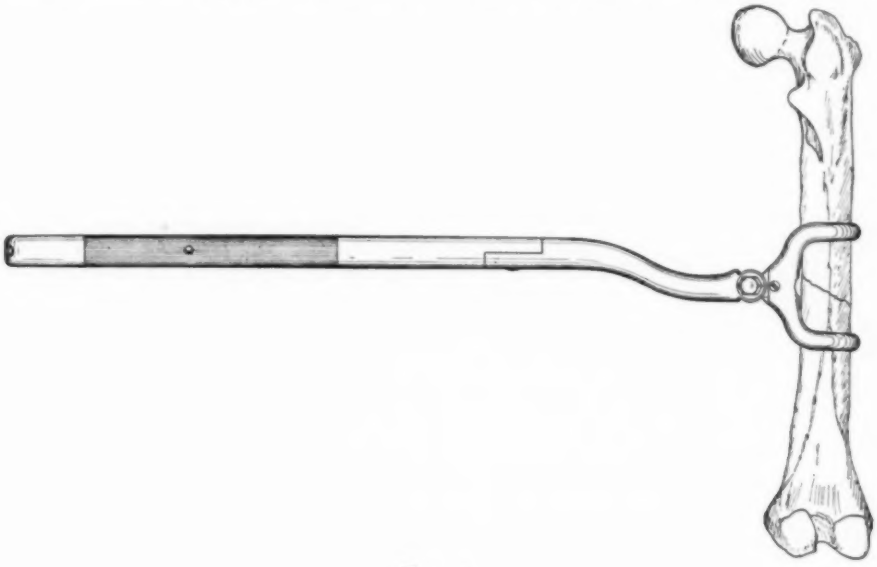

FIG. 1.

Figure 1 shows clamp applied to a reduced fracture.

In Figures 2 and 3, the handle has been placed to either side as desired.

Figure 4 is then seen looking down on the clamp and fracture from the top, illustrating how much more conveniently fixation material may be applied.

The jaws of the clamp, in addition to being hinged, have a swivel lock, permitting adjustment laterally as illustrated in Figure 5. This permits their use at the expanded ends of long bones or wherever the contours of the bone do not run parallel.

Figure 6 A, B, C illustrates the interchangeable jaws and key.

In conclusion I want to state that by the use of the new bone clamp many undesirable operative difficulties can be eliminated.

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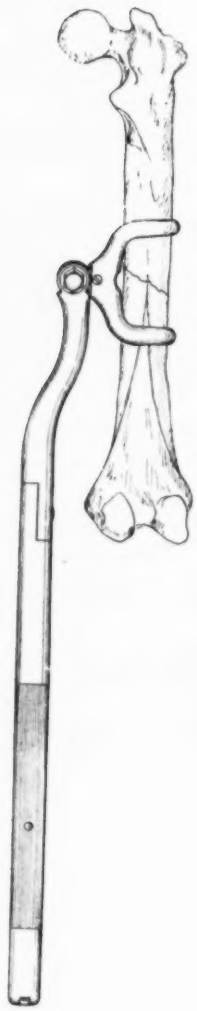

Fig. 2.

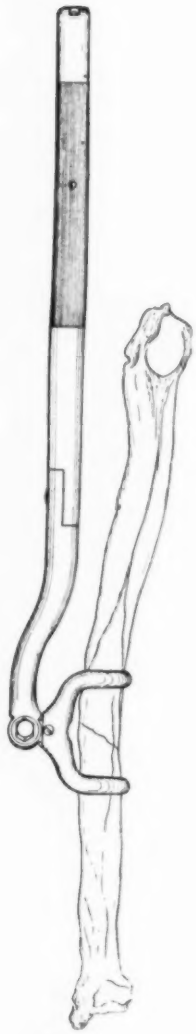

Fig. 3.

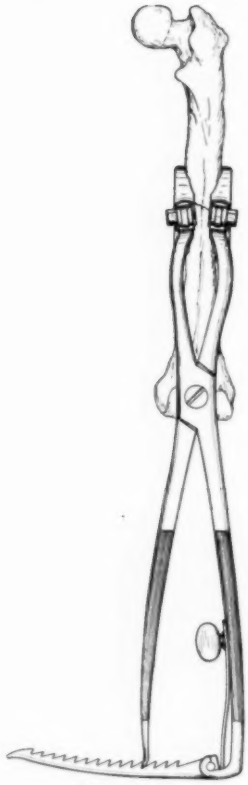

Fig. 4.

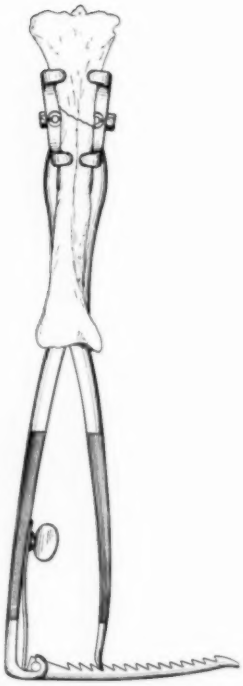

Fig. 5.

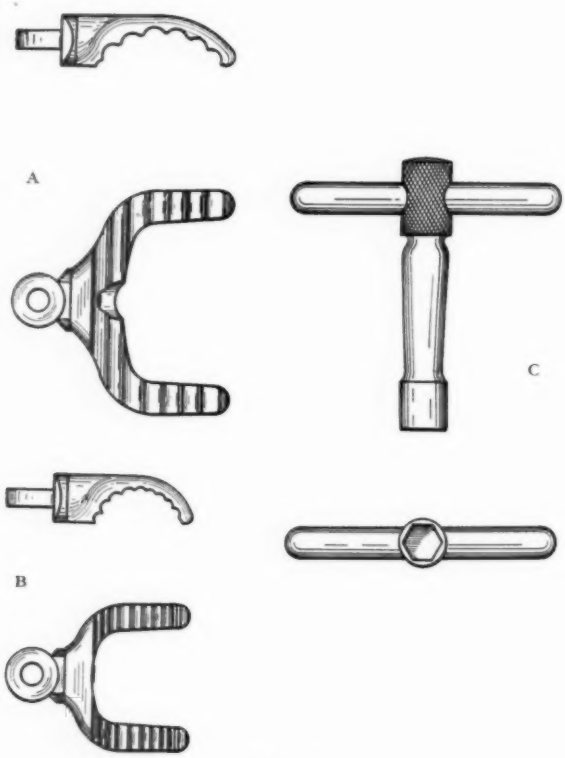

Fig. 6.

AN IMPROVED EXTENSION APPARATUS FOR SKELETAL TRACTION*

P. A. BENDIXEN, S.B., M.D., F.A.C.S.

DAVENPORT, IOWA

IT has been the writer's experience that there are two very important factors to be considered in the treatment of fractures; namely, restoration of function and anatomical alignment.

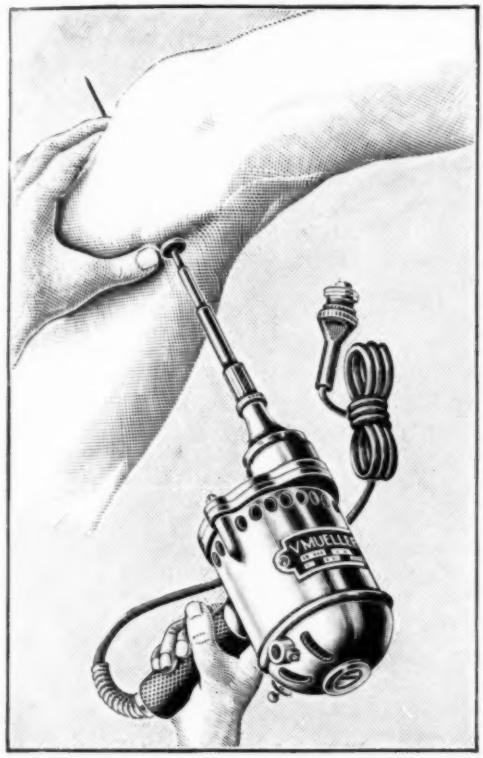

FIG. 1.

The anatomical reposition of a fracture must be accomplished by manipulation, and after reduction must be held in place by traction during part or all of the healing period. Various methods of extension have been tried and applied but the one recommended by Kirschner fulfills the purpose better than any other.

In order to accomplish these results the surgeon must possess certain instruments and armamentarium which are simple in construction and not prohibitive in price. With these ideas in view the author devised and simplified the Kirschner clamps and instruments.

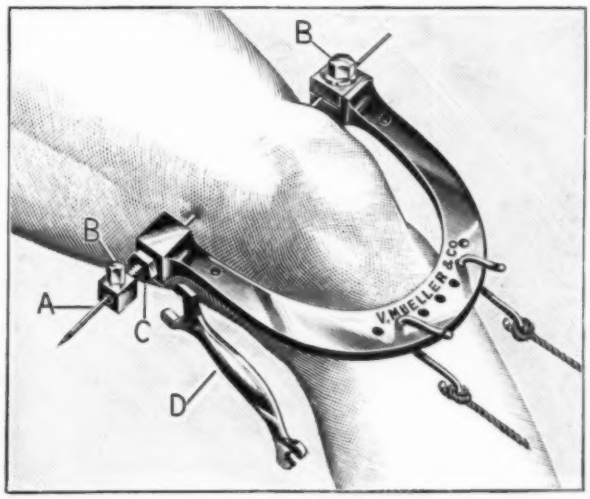

FIG. 2.

To the author's special motor is attached a telescope supporting apparatus which holds the extension wire as illustrated in Figure 1.

After the wire has been introduced through the bone it is placed in the traction bow and the necessary tension put on the wire by a very simple extension bolt as illustrated in Figure 2, point C. The tension on the wire is made by means of the wrench D at point C; after the desired traction has been made it is fixed at points B.

Figure 3 shows author's complete motor set including wire and telescope supporting apparatus (the telescope supporting apparatus can be fitted for other type of motor).

Figure 4 shows author's complete set of simplified extension bows.

In conclusion the author wishes to state that the Kirschner method if properly used, in certain groups of cases, will greatly assist the surgeon in the alignment of his fractures, which will spell better functional end results.

*Submitted for publication December 15, 1931.

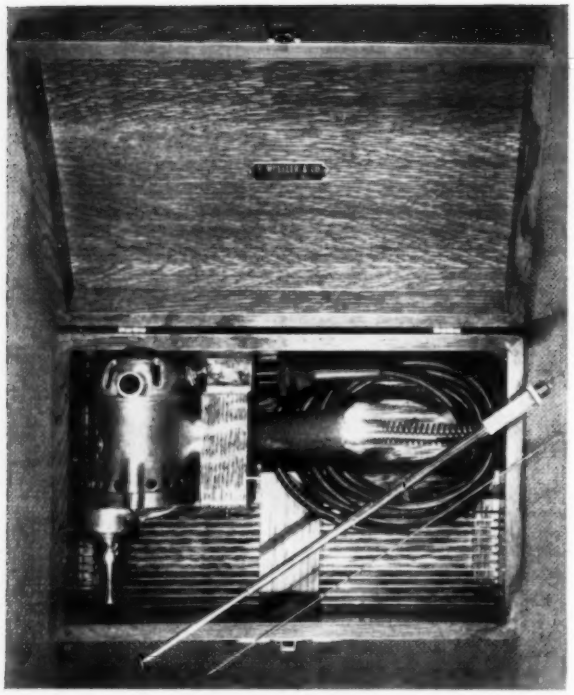

FIG. 3.

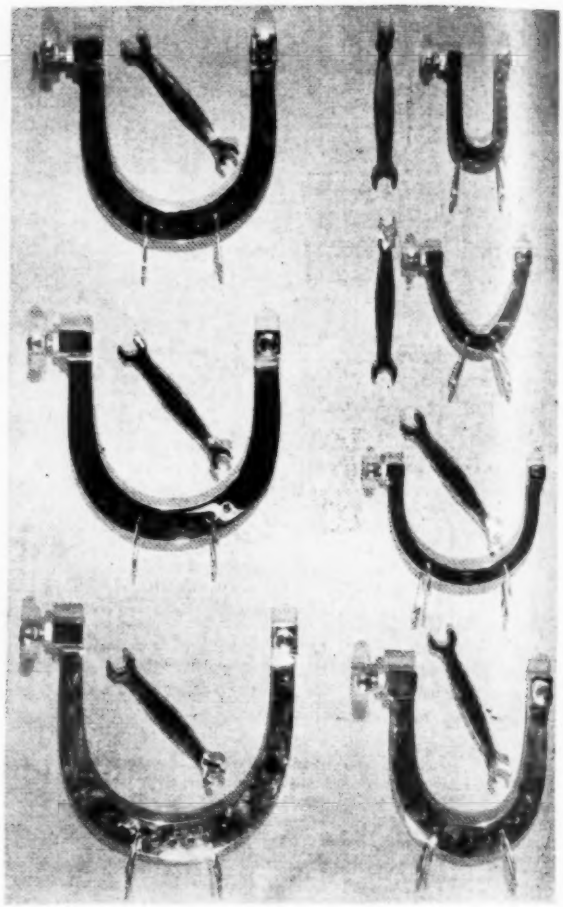

FIG. 4.

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* Continued from p. 340.

CLINICAL MANAGEMENT OF THE HORSESHOE KIDNEY

Part III (Conclusion)*

Robert Gutierrez, M.D., F.A.C.S.

NEW YORK

X. Report of Cases

Summary of 19 Cases of Horseshoe Kidney Disease with Preoperative Diagnosis

Case 1. D. S., aged eighteen, male, hospital No. 282,425 admitted Oct. 15, 1928.

Résumé of Symptoms: Patient is a thin, well developed young man but very anemic, lying in bed and acutely ill, complaining chiefly of pain in epigastrium and umbilical region, marked frequency of urination and nocturia, dysuria, pyuria, nausea, vomiting, headache and high temperature. Duration three weeks. He had been treated for persistent chills and fever of undetermined origin, until he came under my observation. On physical examination the abdomen is much contracted and rigid, both kidney regions tender and painful on palpation. Patient stated that attacks of intermittent pain have occurred for several years and chronic constipation has been present from birth. He claims that he has been using enemas daily, from childhood, and his bowel troubles have been accompanied by persistent pain in the umbilical region and across his back which has made him unfit to work or to attend to his duties at school.

Cystoscopic Findings and Functional Renal Tests: Bladder mucosa chronically inflamed, multiple cellules and trabeculations. Both ureteric orifices markedly congested and interureteric ridge of trigone markedly hypertrophied. Both ureters catheterized. Phenolsulphonephthalein appeared on right side in two and one-half minutes, on left in ten minutes. Urine from bladder foul and purulent. Urine culture negative.

Roentgenography: No shadow indicative of stone in urinary tract. The shadow of the right kidney is irregular and low in position, about the level of the fourth lumbar vertebra, and there is an indefinite shadow, suggesting the isthmus of a horseshoe kidney.

Urographic Findings: Right pyelogram, moderate degree of hydronephrosis; pelvis is turned and the calices point inward toward the spinal column. Left pyelogram, slight hydronephrosis with rotation of pelvis and calices, which point inward.

Diagnosis and Type of Lesion: Horseshoe kidney with bilateral hydronephrosis and pyelonephrosis infection plus pyelitis and pyelonephritis.

* Part I appeared in the December, 1931 issue, vol. 14, p. 657, and Part II in the January, 1932, issue, vol. 15, p. 132.

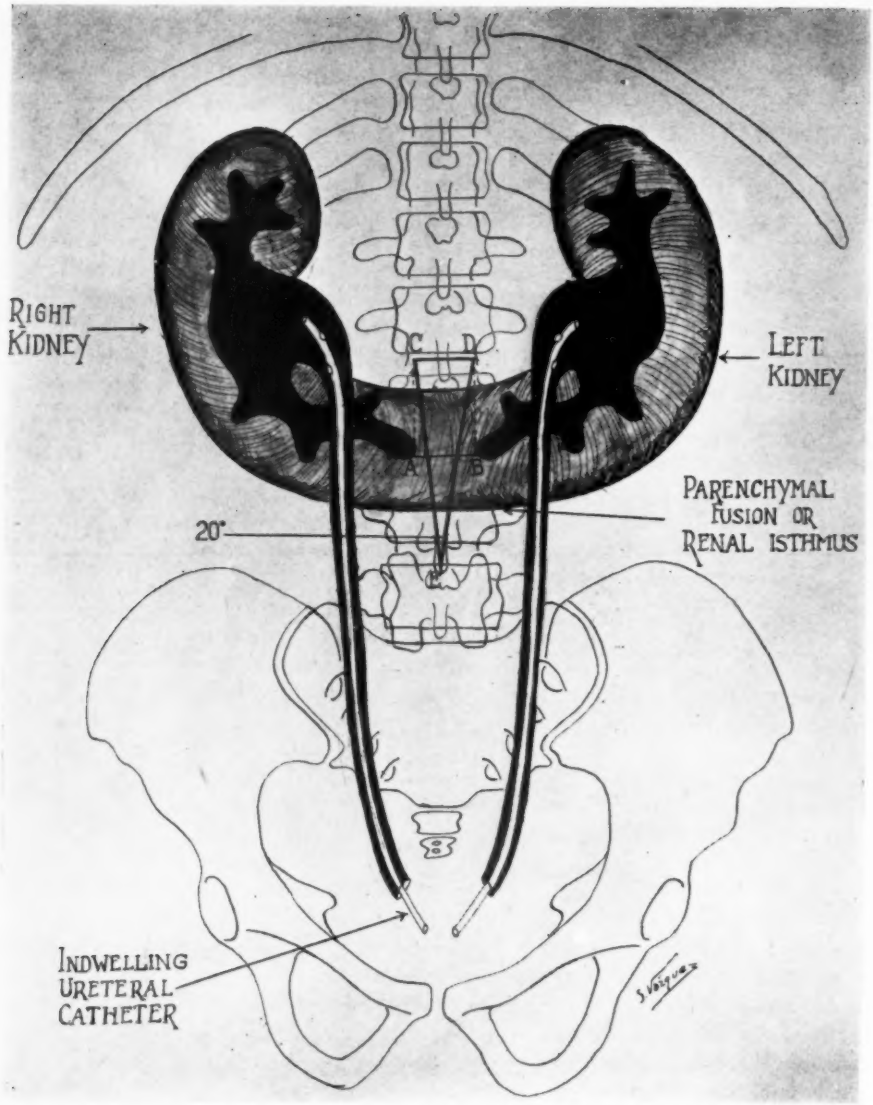

FIG. 41. Drawing made from Case 1 to illustrate the value of the medical and urological treatment in acute cases of horseshoe kidney disease with evidence of urinary stasis, pyelitis and pyelonephritis, particularly when using the method of the indwelling ureteral catheter to secure drainage, to relieve pain and infection and to prevent fatal uremia. Note also the presence of the *minimum basal angle of the pyelographic triangle of the horseshoe kidney.*

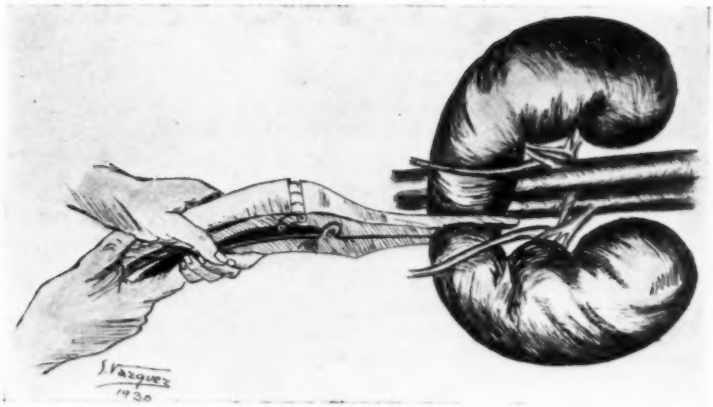

FIG. 42. Represents the first step in the operation of renal symphysiotomy for division of the parenchymal isthmus in horseshoe kidney disease.

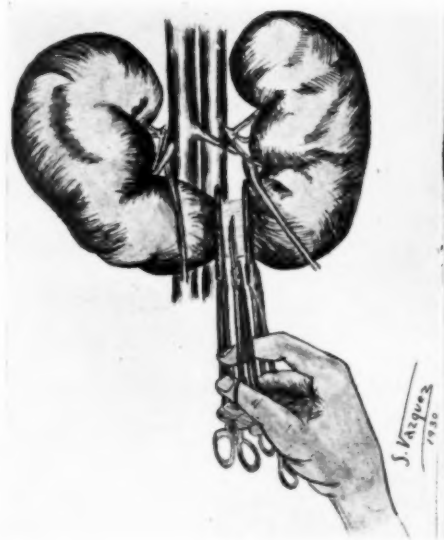

FIG. 43. FIG. 44.

FIG. 43. Illustrates the second step of the operation of renal symphysiotomy in normal horseshoe kidney as the only possible means of obtaining permanent relief from symptoms and ultimate cure.

FIG. 44. Represents the final step in the technique of the renal symphysiotomy operation, which consists of separation of the two kidneys from their incarcerated position upon the aorta and vena cava, followed by suture of the raw surfaces of the cut renal isthmus. This operation appears to be the ideal method of treating the entity of horseshoe kidney disease. (Redrawn from Rovsing's case.)

Pathological Observations: At times uremic with temperature up to 104°F. Pulse very irregular and rapid. Difficulty in breathing and in precordial region. Persistent pain in epigastrium, rigidity of abdominal muscles and vomiting. General weakness, poor circulation of extremities with edema and cyanosis of both legs.

Treatment: Medical: Urinary antiseptics, urotropin and sodium acid phosphate, *t.i.d.* Intravenous infusion of saline solution, cathartics and high colonic irrigations, forced fluid, rest in bed, heat to kidneys and extremities, etc. *Urological:* Indwelling ureteral catheters to secure drainage and relieve pressure; kidney pelvis irrigations with acriflavine 1:10,000 to correct infection and prevent inhibition of kidney function. *Surgical:* None.

Results and Observations: Left hospital in two weeks, apparently cured of acute symptoms. Two months later still complained of pain in epigastrium and in both kidney regions. Urine hazy and never free from pus. Patient is thin, abdomen much contracted; still complains of chronic constipation for which he uses enemas daily and cathartics. Cystoscopic treatments, with dilatation of ureters and kidney pelvis lavage, have been carried out on various occasions and relieved the symptoms somewhat, but patient states that while he is feeling much better he is not entirely well, and that the cause of his trouble has never been explained to him before. Symphysiotomy operation proposed but in view of his improvement the patient went South and no further data have been obtained.

CASE II. B. C., aged twenty-nine, male, hospital No. 284,810, date of admission Feb. 23, 1929.

Résumé of Symptoms: Burning on urination, pain on left side, duration five days. Hematuria and pyuria. Occasional rise of temperature and chills.

Cystoscopic Findings and Functional Renal Tests: Interior of bladder negative. Both ureters catheterized without obstruction. Phenolsulphonephthalein on left side in nine minutes, on right no appearance. Urine culture negative.

Roentgenography: No shadow indicative of stone in urinary tract. Shadow of left kidney much larger and lower than that of right.

Urographic Findings: Right pyelogram shows a typical arrangement of the calices of a horseshoe kidney. Left pyelogram shows complete excavation of the left kidney, with infectious hydronephrosis.

Diagnosis and Type of Lesion: Horseshoe kidney with bilateral pyelonephritic infection and left hydronephrosis.

Pathological Observations: High temperature, severe pain in epigastrium, at times uremic symptoms.

Treatment: Medical: Urinary antiseptics. *Urological:* Indwelling ureteral catheters with kidney pelvis irrigations. *Surgical:* None.

Results and Observations: Improved, and discharged March 30, 1929.

CASE III. M. D., aged twenty-one, male, hospital No. 175,268, date of admission May 5, 1930.

Résumé of Symptoms: Pain in lower right quadrant, also slight pain in umbilical region. Slight frequency and dysuria. Patient entered hospital with a provisional diagnosis of appendicitis.

Cystoscopic Findings and Functional Renal Tests: Bladder chronically inflamed throughout. Both ureters catheterized but catheter met obstruction on right side about 2 cm. from ureteral orifice. Phenolsulphonephthalein appeared on right side in seven minutes, on left side in three minutes. Culture of urine showed negative growth.

Roentgenography: Left kidney shadow is lower and larger than that on the right and the actual lower poles of both kidneys are not seen. There is a small shadow in contact with the catheter just opposite the third sacral foramen on the right side, revealing the presence of a small stone impacted in the lower ureter.

Urographic Findings: Bilateral pyelograms taken on April 28, 1930, reveal horseshoe kidney. Also later, on May 13, 1930, uroselectan pictures, twenty minutes after intravenous injection, showed a beautiful shadow of the entire urinary tract and the calices of both pelves pointing towards the median line. A filling defect of a round calculus was seen in the lower end of the right ureter.

Diagnosis and Type of Lesion: Horseshoe kidney, bilateral pyelitis, calculus in right lower ureter.

Pathological Observations: At times severe attacks of pain in right lower quadrant and umbilical region with rise of temperature.

Treatment: Medical: Urinary antiseptics, rest in bed, cathartics and forced fluid.

Urological: Cystoscopy, dilatation of ureters, lavage of kidney pelvis with revonol dextrose 1:5000. Indwelling ureteral catheter at times.

Surgical: None.

Results and Observations: Patient left hospital after four weeks with the diagnosis just given and feeling better, but in still receiving cystoscopic treatment. His general condition is improved.

Case IV. J. T., aged fifty, male, examined Dec. 20, 1926; presented here by courtesy of Dr. Hernandez of Havana. Chief complaint, pain in epigastrium for over twenty years, gastric trouble for several years. Pain in both renal regions with dysuria and intermittent attacks of hematuria.

Physical examination revealed that both kidneys were painful on palpation of abdomen, and a definite tumor mass was easily made out on the left side which apparently ran across to the opposite side where another definite hard tumor mass was also palpable. Urine analysis showed microscopic pyuria and hematuria and a trace of albumin and casts. January 2, 1927, a plain *x*-ray revealed the presence of a gigantic bilateral renal calculus occupying the entire site of both kidney pelves. On the right side there were two unusually placed shadows about the size of a lime, quite close to the spinal column at the level of the third and fourth lumbar vertebrae and near the midline. On the left side the shadow of the coraliform stone which was about the size of an orange, occupied the entire area of the left kidney pelvis and appeared to be rotated inward with the calices or branches of the stone pointing to the spinal column. A definite diagnosis of horseshoe kidney with bilateral nephrolithiasis could be made from the plain *x*-ray pictures.

Patient was cystoscoped January 13, 1927, and a right pyelogram taken, confirming the diagnosis of horseshoe kidney with bilateral renal stone and marked diminution of renal function. Blood chemistry figures at that time were pretty high, and in view of patient's general unsatisfactory condition palliative treatment alone was recommended.

Case V. W. L., aged fifty, male, hospital No. 269,959; a well developed individual with blood pressure 120/92, admitted to the Urological Department of New York Hospital Nov. 10, 1926. Patient came to the clinic complaining of pain in both kidney regions and in bladder of over thirty years' duration, but more severe for the last two months during which it has been accompanied by frequency of urination, dysuria and changing flow of urine. He also had an attack of acute retention for which he entered the hospital.

For the past ten years he has been having a great deal of trouble physically and has had medical treatment for neurasthenia and general bodily weakness, also prostatic

massage and bladder irrigations. Fifteen years ago he had a perineal operation for drainage of seminal vesicles and three months ago an abdominal operation in another hospital at which horseshoe kidney was discovered but no relief of abdominal pain obtained.

Physical examination revealed a large scar at the left side of the abdomen with slight tenderness on deep pressure. There was suprapubic dulness extending to the umbilicus. Rectal examination disclosed an enlarged prostate, leading to a diagnosis of hypertrophy of prostate with complicating phlebitis and chronic cystitis, for which a suprapubic cystotomy was done Nov. 16, 1926.

Patient was discharged from hospital January 19, 1927, with a suprapubic drainage tube and with his general condition improved; readmitted to hospital March 4, 1927, complaining of marked pain in the abdomen and bladder region, with slight fever; he was carrying a suprapubic Pezzer catheter which was not working satisfactorily. This was replaced by a double suction tube, and a Young punch operation under regional anesthesia was planned to be carried out as soon as the general condition should warrant it. The patient was discharged and advised to return to the hospital after a period of convalescence when perineal prostatectomy was also to be considered.

Nov. 10, 1926, cystoscopy revealed a normal bladder mucosa except for marked congestion of the trigone, considerable intrusion of the subcervical group and moderate infringement of the lateral part of the prostate. Both ureters were catheterized and the renal function was found about equal on both sides. The roentgenogram revealed the shadow of the left kidney larger than usual, giving the impression of polycystic kidney disease. In the left pyelogram, the kidney was unusual in shape and turned inward, giving a definite impression of an infected horseshoe kidney. The second admission was on March 4, 1927, and the discharge on March 11, 1927, with the result unimproved. No further surgical treatment was carried out and two weeks later patient died of pneumonia. No autopsy was secured.

Case VI. B. L., housewife, aged forty-three, hospital No. 269,385, Russian, admitted to New York Hospital Oct. 6, 1926, with diagnosis of chronic constipation and pain in lower abdomen for over two years. An operation in some other hospital for chronic appendicitis had brought no relief. Patient is married and has four children, living and well. She has been suffering with occasional attacks of dull, recurring pain in right lower quadrant of abdomen, for a period of nearly twelve years, which at times radiated across abdomen and around the back on both sides. For the last two years since the appendectomy operation, pain has been constantly present in varying degrees, at times fairly severe. It has been slightly more marked in the morning following a night's rest, and has sometimes been relieved by enemas and morphine. During the past few months the pain has gradually become worse.

For past year and a half patient has been compelled to take daily enemas. She stated she had been constipated all her life but never to such a marked degree as now.

For the last six months there has been slight gastric trouble with marked gaseous eructations and meteorism, but no vomiting or pain after meals.

The menstrual history has always been regular except that in the past year patient has had "severe pain" throughout duration of menstrual periods.

Urine analysis has always been negative. But during past six months patient has had a very noticeable polyuria, with frequency during day of ten to fifteen times, and during night of two to three times. No pyuria or hematuria has been present at any time. Physical examination was essentially uninteresting. All sorts of examination in general hospital had been undertaken in order to find a possible cause of her symptoms but she was discharged Oct. 16, 1926, with the diagnosis of chronic constipation and

indefinite colon pathology, and with the results of improvement. Patient was readmitted to the hospital Nov. 14, 1927, with the same complaint. But the undetermined abdominal pain, particularly in the umbilical region, has been more severe, and she has also developed rectal tenesmus, for which proctoscopic examination was carried out but proved negative. *X*-ray with barium enema and barium meals did not disclose a true pathology in the colon or gastrointestinal tract. As the patient had pollakiuria and dysuria and pus cells in the urine, she was referred to the urological department for cystoscopic examination. Cystoscopy Oct. 14, 1926, revealed a normal bladder except for an unusual mucosa that was folded over itself with marked trabeculations and cellules. Both ureters were catheterized and renal function found to be normal. The left pyelogram, however, revealed a rotated kidney pelvis with shaggy and dilated calices, giving the impression of horseshoe kidney as the definite cause of her trouble. A diagnosis of horseshoe kidney with pyelonephritis was accordingly made and patient was discharged improved Nov. 18, 1927, after a few cystoscopic treatments and kidney pelvis lavage.

Case VII. M. S., aged thirty-two, male, examined by Dr. Hernandez of Havana May 25, 1926. Chief complaint renal colic and gastric trouble on different occasions; also pollakiuria, dysuria and pain in both kidney regions and in epigastrium, on deep palpation.

Physical examination and urinalysis negative. Roentgenography disclosed the presence of shadows of a urinary calculus in the area of the pelvis and calices of the right kidney. Cystoscopy May 30, 1926, revealed a diffused cystitis and a good renal function. Right pyelogram showed that the opaque medium obscured the original shadows of stone and that the pelvis was rotated with calices reversed and pointing toward the spinal column, thus revealing the diagnosis of horseshoe kidney with stone in the right side. The right kidney was exposed and heminephrectomy done. Patient had an uneventful convalescence.

Case VIII. A. M., aged twenty-six, female, has been complaining for several years of chronic appendicitis with indefinite pain on the right lower quadrant. Also has pain across her back.

Cystoscopy on June 7, 1929, revealed two ureteral orifices on the left side and one opening normally on the right side of the trigone. The three ureters were catheterized and specimens collected and sent to the laboratory for culture, and for urea and microscopical examination. Phenolsulphonephthalein 1 c.c. injected intravenously appeared from the three ureters in three to four minutes with normal concentration. The culture of urine was negative. Roentgenography revealed no shadow indicative of stone in the urinary tract. The right pyelogram showed infection of two parts of the double pelvis with a very peculiar arrangement of both the pelves and the calices, giving the impression that the two pelves reached the common ureter and that the whole organ was rotated inward as in horseshoe kidney. A week later a pyelogram of the two ureters and two corresponding kidney pelves on the left side revealed also the fact that these were rotated toward the spinal column and thus confirmed the presence of a congenital anomaly of four pelves and four incomplete ureters in a horseshoe kidney. Since this diagnosis has been established, the treatment carried out has been the routine cystoscopy, dilatation of the ureters and kidney pelvis lavage, which brings relief and very satisfactory results in clearing up the pyelonephritic infection. The microscopical examination of sediment has shown that the urine collected from each kidney pelvis contains occasional pus cells, epithelial cells and many red blood cells. The culture of the urine from the bladder and from each kidney pelvis has at all times been negative. Apparently patient is improving under the routine urological treatments.

CASE IX. M. K., aged fifty-eight, female, had always been in good health, but complained of slight backache for the last ten years. In the last few months she has noticed frequency and painful urination, for which cystoscopy was performed, revealing a normal bladder with ureteral orifice slightly congested, as were also the trigone and vesical orifice. The ureters were catheterized with a No. 6 French catheter. The renal function was good from both sides. Bilateral pyelogram on March 14, 1929, revealed a peculiar shape of pelvis with marked rotation and the calices opening toward the midline. The ureters were somewhat distorted and dilated but apparently fell within normal limits. They reached the pelvis in a peculiar and abnormal angle, their direction alongside of the spinal column making a wide-mouthed "flower vase" figure as if approaching each other above and carrying the contents of a horseshoe kidney. After the diagnosis was established, patient was submitted to cystoscopic treatment with dilatation of the ureters and kidney pelvis injection with a solution of revonol dextrose 1:2000. In addition, because the position of her kidney shadow was lower than normal, she was given a kidney belt to support the organ. While her general condition has improved, her symptoms have not entirely disappeared. It seems, therefore, that no definite cure or relief of symptoms can be obtained until the isthmus of the horseshoe kidney is divided by the symphysiotomy operation, separating the fused organ into two separate organs, and thus relieving the continuous pressure that the isthmus of the horseshoe kidney exerts upon the aorta and vena cava and upon the nerve supply of the same.

CASE X. F. L., male, Italian, aged thirty-two, hospital No. 274,340, was admitted into the Urological Department of the New York Hospital July 21, 1927, complaining of swelling of left testicle of three and one-half years' duration, also dysuria and frequency. Patient states that in the past he has had attacks of renal colic, frequency, hematuria and intermittent pain in right lumbar region. He further states that an operation was done in Italy fourteen years ago for the removal of stone from the right kidney, since which time he has been suffering with abdominal pain. The diagnosis made was left chronic epididymitis and left seminal vesiculitis, and on July 22, 1927, under local anesthesia left epididymectomy was done for a tuberculous epididymis. The vas deferens was transplanted to the surface of the skin about 1 in. below Poupart's ligament and above the external inguinal ring. Patient made an uneventful recovery and was discharged from the hospital on July 30, 1927. The laboratory report of the specimen proved that the epididymitis was of a tuberculous nature. Patient was readmitted to the urological service on Sept. 9, 1929, with swelling of right side of scrotum of over four months' duration. A right hydrocele with a chronic right tuberculous epididymitis was diagnosed, for which he was operated upon on Sept. 10 under local anesthesia. Right hydrocelectomy and epididymectomy were carried out in the usual manner. Again patient had an uneventful recovery and was discharged Sept. 19, 1929. Two weeks later he came back complaining of pain on the upper right quadrant where he had the scar of a previous kidney operation. Cystoscopy was done, and a plain roentgenogram and a right pyelogram taken, revealing that the right and left kidney shadows were indefinite but appeared to be low in position, giving the impression of a union between the two kidneys in the midline. The pyelogram thus indicated the presence of a horseshoe kidney with an excavation of the right pelvis and the presence of a pyohydronephrosis presumably of tuberculous origin and representing the primary focus of tuberculous infection of long standing. The calices were shaggy, distorted and dilated, the lowermost ones pointing inward toward the midline, thus confirming a definite diagnosis of horseshoe kidney. No further operation was considered in this case and the patient has been receiving the

usual anti-tuberculous treatment in the postoperative tuberculosis clinic of the hospital with the diagnosis of renal tuberculosis on the right side of a horseshoe kidney.

CASE XI. G. P., history No. 273,151, merchant, thirty-five years of age, admitted May 16, 1927, complaining of pain in left lumbar region of over four years' duration; had been operated on elsewhere for appendicitis, but indefinite pain in the umbilical region persisted after appendectomy. Had experienced a severe attack of pain on left side with marked urinary disturbances six weeks previous to admission to hospital. Cystoscopy and left pyelography were done and plain *x*-ray pictures of the genitourinary tract also taken. The latter showed a round shadow opposite the transverse process of the fourth lumbar vertebra on the left side, disclosing further the presence of a stone at the level of the left ureteropelvic junction. The kidney shadows on both sides were particularly interesting in that they were apparently connected by an isthmus at the lower pole, forming a typical horseshoe kidney. The left pyelogram showed a bifid pelvis, with the calices of the upper portion of the kidney dilated and shaggy, pointing backward and laterally, while those of the lower portion pointed markedly inward toward the spinal column, thereby revealing the presence of a horseshoe kidney with infection and stone in the ureteropelvic junction on the left side. The patient was advised to have dilatation of ureters and kidney pelvis lavage, in an attempt to allow the stone to pass and to overcome the infection. The renal function on each side was sufficient in regard to urea excretion and phenolsulphonephthalein elimination. Microscopical examination of sediment showed pus cells 20 per field on the left, and blood and epithelial cells 3 per field on the right. After several cystoscopic treatments, the stone moved down into the intraumural vesical portion of the ureter and was removed from the left ureteral orifice with the Lowsley irrigating rongeur. Patient was discharged from the hospital two days later as improved but with the diagnosis of horseshoe kidney.

CASE XII. J. de R., male, Italian, aged twenty-two, History No. 262,783. Student by occupation, well nourished and well developed but appearing acutely ill on August 27, 1925, when he was admitted to hospital, his chief complaint being pain in left kidney region and severe pain in rectum.

Physical examination revealed a very rigid and contracted abdomen. Blood pressure systolic 210, diastolic 110. Patient was brought to hospital on the theory that the severe pain in left kidney region was due to a ureteral obstruction from an impacted stone in the pelvic ureter. Blood chemistry showed urea retention up to 167.90, thus revealing the critical condition of the patient, who was uremic and unconscious. Twelve years ago a stone had been removed from the bladder by cystoscopic manipulations. Eighteen months previous to admission to the urological department patient had undergone an operation for appendectomy elsewhere. A relative stated that at the time of the appendectomy the surgeon had told him that the patient had an enormous kidney (?). On August 28, 1925, the patient was cystoscoped. A considerable amount of cloudy and foul urine was removed from his bladder, and after a profuse washing the bladder mucosa appeared very much injected throughout, containing many particles of pus on its surface. There was a bulging at the vertex of the bladder, apparently due to some external pressure. No stones, tumor masses, diverticula or ulcerations were seen in the urinary bladder. Both ureters were catheterized and a left pyelogram was taken, about 15 c.c. of sodium iodide being injected into the left kidney pelvis. After the picture was taken the catheter was reinserted, the sodium iodide allowed to drain off, the kidney pelvis irrigated with sterile water, and the instruments and catheters removed. Patient was sent to ward in fair condition. The pyelogram revealed an unusual shape of pelvis which at first was thought to indicate a polycystic kidney, but in view of the fact that the

pelvis was rotated and that the calices were inverted, pointing toward the vertebral column, a diagnosis of horseshoe kidney was made. The patient's general condition appeared to be better for a day or so, but on Sept. 3, 1925, it became aggravated, with a high temperature and the blood urea rising as high as 261.28. Despite every care and attention patient died on Sept. 6, 1925, from acute uremia due to an infected horseshoe kidney condition.

CASE XIII. A. B., a Russian woman, aged twenty-four, admitted to medical division of the New York Hospital and later on January 17, 1927, transferred to Urological Department, history No. 271,004. She had been complaining of severe pain in both kidney regions with intermittent attacks of hematuria and pyuria over a period of several years, accompanied with burning and difficulty of urination, which symptoms have become aggravated in the last two weeks. She has also been suffering with marked chronic constipation all her life. On physical examination the abdomen was very much contracted and there was definite pain on palpation in the umbilical region and also on the right lower quadrant. Patient was cystoscoped and a right and left pyelogram taken revealing the presence of a rotated pelvis irregular in shape, with the lower calices pointing inward toward the midline thus demonstrating the presence of an infected horseshoe kidney. Three days after admission she became suddenly hysterical and delirious, and developed a mental complex for which she was transferred to Bellevue Hospital for further observation and treatment. No further information has been recorded in this case.

CASE XIV. J. R., male, aged forty-four, admitted to the clinic of the Urological Department of the New York Hospital on Jan. 14, 1930, history No. 172,381. Although appearing in good health, he stated that he had been receiving medical attention for the last fourteen years for various conditions for which he had been treated in several hospitals. These conditions according to his statements have been arthritis, rheumatic pain, stomach trouble and also ulcer of the stomach. He also stated that so far no treatment has relieved his complaint and that he came to the clinic of the New York Hospital mainly because of difficulty and frequency of urination and indefinite pain in upper abdomen. A careful history and check up in connection with this series of horseshoe kidney cases have revealed very striking clinical evidence of this longstanding disease.

Chief Complaints: (1) Pain in epigastrium and umbilical region of two years' duration.

(2) Pain on left leg with edema of right foot and sensation of cold, due probably to lack of circulation.

(3) Marked chronic constipation. Patient has had to have a daily enema and laxatives every other day for the last two years.

(4) Gastric trouble, sensation of fulness, gastrointestinal disorders. Patient claims that other doctors have told him he has ulcer of the stomach, but he has good appetite and has lost neither blood nor weight.

(5) Difficulty and frequency of urination, marked dribbling. Nocturia two to three times.

(6) Attack of right renal colic one year ago but never has had hematuria.

(7) Persistent pus in urine and sometimes dysuria.

Family History: Patient born in Russia, has one sister and 12 brothers, 2 of whom are twins. Father is eighty-six years old, living and in good health Mother died twenty-one years ago of pain in the middle of the abdomen and probably same sort of kidney trouble as that of which patient is complaining.

Personal History: Patient has had the ordinary childhood diseases without incidents. The first clinical manifestations of the present trouble started twenty-three years ago after he had been in the military service abroad. During a long stretch of walking, he was

seized with a sudden attack of pain in the middle of the abdomen. There was also pain in the right leg with a sensation of cold in the same, which made it impossible for him to continue in the army. The second attack of clinical manifestations appeared again fourteen years ago with the same symptoms as before but now more severe. A third similar attack of illness occurred two years ago with all the classic symptoms described here, from which he is still suffering at the present time.

Physical Examination: Patient is well developed and well nourished for a man of his age, and weighs about 155 lb. The abdomen was quite distended and on deep palpation on the right flank a definite mass could be made out which was tender to the touch and was presumably the kidney, which, apparently running across the midline, presented a resistant body below the area of the umbilicus. Also on the left side on deep palpation, lower than normal and in the left lateral portion of the middle of the abdomen, there could be detected a resistant mass of unusual shape and tender on palpation, giving the impression of a possible ectopic fused kidney.

External Genitals: Normal. Rectal examination negative. The urine, first and second glasses, was clear and the third was slightly hazy.

Cystoscopy and Renal Functional Test: On January 18 patient was cystoscoped after meatotomy. The interior of bladder was negative. Both ureters were catheterized and specimens sent to the laboratory for culture and for urea and microscopical examination. The report of the ureteral specimen was as follows: Character bloody, urea and phenolsulphonephthalein elimination from both sides equally good. The culture was negative.

Roentgenography and Pyelography: The *x*-ray report of the genitourinary tract was negative to shadows of urinary calculi, but revealed a most interesting shadow of a fused organ, as in horseshoe kidney. The right pyelogram showed a bifid type of kidney pelvis with some shagginess of calices and slight distortion of the pelvis, but apparently the pelvis was in normal position. Two weeks later patient was cystoscoped again and a left pyelogram taken, which revealed also a slight degree of hydronephrosis, but with pelvis and calices apparently normally placed. However, the diagnosis of horseshoe kidney was established and based on the flat *x*-ray picture which corresponds with the clinical findings. Patient has been receiving only urological treatments, routine cystoscopy with dilatation of the ureters and kidney pelvis lavage. He has improved somewhat but is still complaining of the abdominal pressure and other symptoms for which he came to the hospital, and gives the impression that not until the isthmus of the horseshoe kidney is divided by a symphysiotomy operation will he definitely be relieved of his abdominal pain and urinary symptoms.

Case xv. L. H. male, aged sixty-seven, was admitted to the Urological Department of the New York Hospital May 4, 1929, complaining of frequency of urination day and night with intermittent hematuria for the last four years. Also occasional attacks of pain of moderate severity in the left lumbar region. He stated he had suffered with slight pain across his back for more than twenty-four years, which he attributed to rheumatism. All these symptoms have been getting worse during the last month and he entered the hospital for relief. On physical examination a slightly tender mass could be felt on the left upper quadrant. Urinalysis revealed pus 3 plus, blood 2 plus, specific gravity 1.015, acid reaction and appearance hazy with a slight trace of albumin. Wassermann test negative. On May 3 cystoscopy revealed no blood from either ureteral orifice. A No. 6 catheter passed to each kidney pelvis without difficulty. Specimens from each side and also from the bladder were sent to the laboratory for culture, and urea and microscopical examination. Phenolsulphonephthalein appeared on the left side in five minutes, on the right in nine minutes. The urea concentration was 25 gm. per liter on the right, 18 gm.

FIG. 45. Plain roentgenogram of Case XV revealing a shadow of a renal calculus in the area of the left kidney, and in contact with the ureteral catheter.

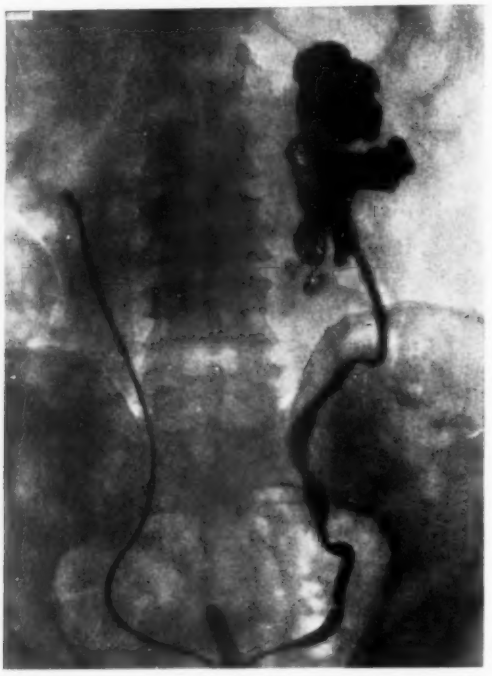

FIG. 46. Left pyeloureterogram of same case, revealing rotation of pelvis with the lower calices turning inward toward the midline, and assuring the presence of a horseshoe kidney. Also hydronephrosis covering the previous shadow of the renal calculus.

on the left. The microscopical examination of sediment showed pus cells on the left side. Culture was negative. Plain *x*-ray pictures and left pyelogram were taken. The roentgenographical report revealed the presence of a shadow in the area of the left kidney, apparently

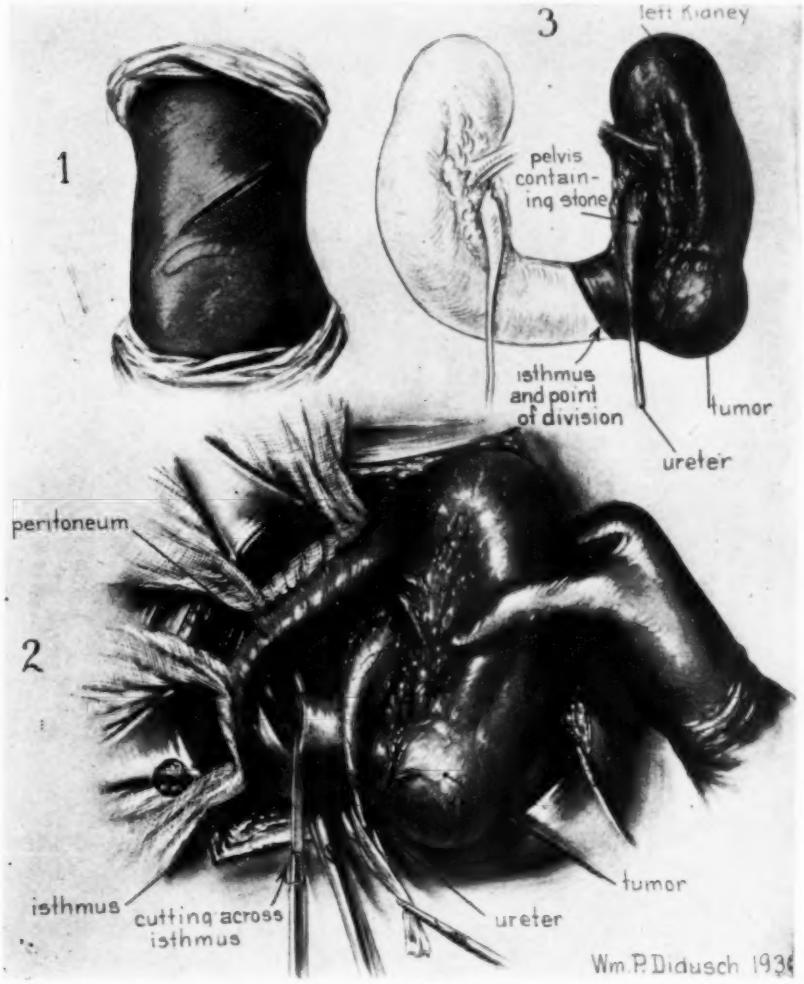

FIG. 47. Drawing of the operative technique in Case XV where heminephrectomy was performed with success. 1. Oblique lumbar incision. 2. Exposure of the left half of the horseshoe organ and the division of the isthmus. 3. Showing the horseshoe kidney and the incision carried out in the isthmus where the left half of the viscuc was removed (De Vries and Lowsley's case).

a renal calculus. The left pyelogram showed a very much dilated pelvis with shagginess and evidence of chronic infection, covering the previous shadow of the renal calculus. The pelvis was unusual in shape, slightly rotated with the lower calices pointed toward the midline, thus revealing a congenital malformation in the shape of a horseshoe kidney. The patient was operated upon under paravertebral novocaine anesthesia on

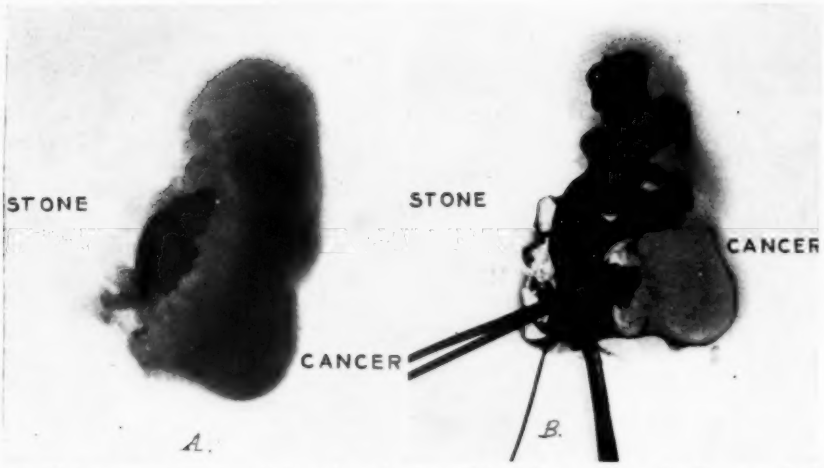

FIG. 48. Plain roentgenogram (*a*) and pyelogram (*b*) of the specimen in Case XV. Left half of horseshoe kidney removed at operation, showing the pathological lesions.

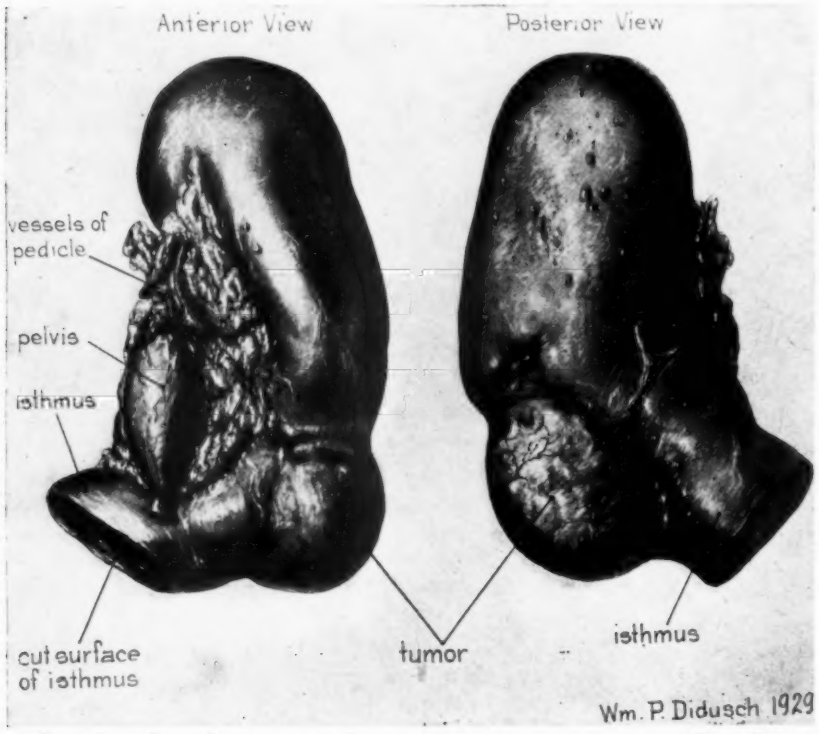

FIG. 49. Drawing of specimen removed at operation in same case, revealing the anterior and posterior surfaces of the left heminephrectomized horseshoe kidney.

May 7, 1929 and the kidney exposed in the usual manner by lumbar incision. The lower pole was found firmly adherent and connected with the kidney of the opposite side by a thick isthmus of parenchymal renal substance. It was easily made out and there was a

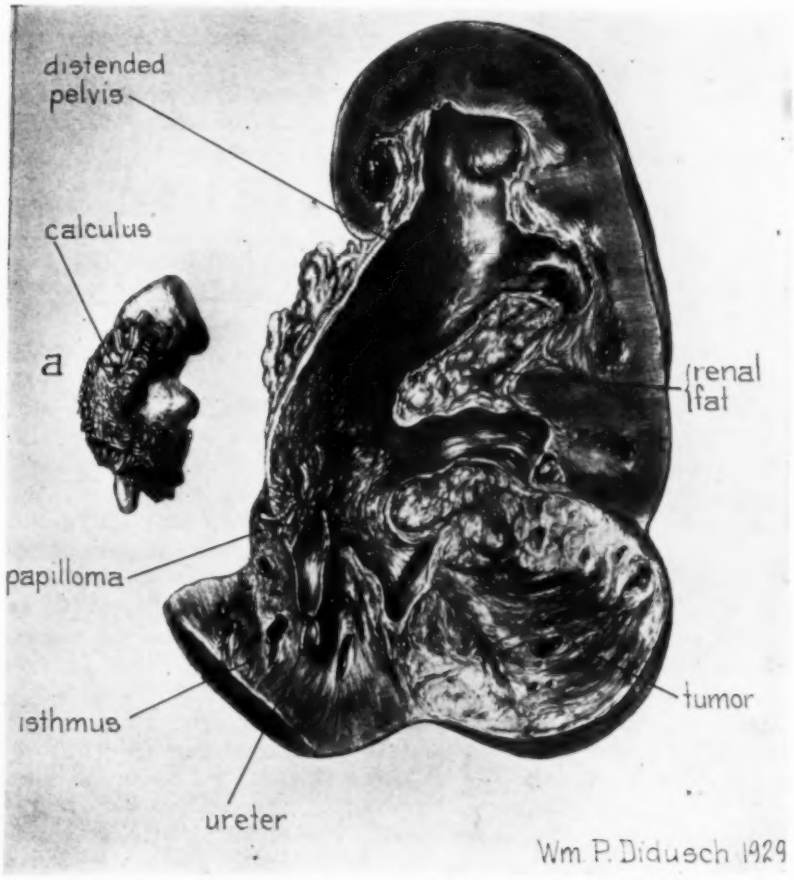

FIG. 50. Sagittal view of the left half of the heminephrectomized horseshoe kidney of Case XV, showing the striking coincidence of calculus, hydronephrosis, papillomata in the pelvis and hypernephroma in the lower pole of the same organ. Patient had an uneventful recovery.

definite indurated mass at the lower pole of the kidney. In view of these findings, heminephrectomy was carried out. The isthmus was clamped and cut across, and after the usual ligature of the ureter and pedicle, half of the left horseshoe kidney was removed. The stump of the raw isthmus was sutured and covered with fat and the edges of the wound brought together without difficulty. Two cigarette drains were placed, one in the renal fossa and the other close to the sutured portion of the isthmus of the horseshoe kidney. The wound was closed in layers in the usual manner and patient had an uneventful recovery, leaving the hospital on May 28, 1929, definitely improved and apparently cured. The pathological report of the specimen removed at operation revealed the half

of a horseshoe kidney with stone in the left kidney pelvis and a tumor at the lower pole of the same half. The histological section of this kidney tumor has been classified as carcinoma. In this unusual case therefore, we find a coincidence of three distinct pathological lesions.

Case xvi. T. S. D., male, aged forty, history No. 288,863, admitted to the Urological Department of the New York Hospital on Sept. 25, 1929, complaining of severe pain on left lumbar region of a few hours' duration.

On physical examination the abdomen was slightly contracted with tenderness extending up into both lumbar regions which makes palpation of the kidney impossible. The patient gave a history of having had on frequent occasions a dull lumbar aching at times in the umbilical region. He had also suffered for several years with mild nocturia and frequency. Sept. 26, 1929, cystoscopy, bladder negative, both ureters catheterized, complete urological examination with functional test done. *X*-ray films revealed no shadow indicative of stone in urinary tract. The shadows of the kidneys were indefinitely made out. Both left and right lower poles appeared to be low in position. Left pyelogram showed a moderate degree of hydronephrosis with a peculiar inverted pelvis and excavation of the left kidney with the calices pointing inward. Right pyelogram showed distorted calices with a somewhat rotated pelvis pointing toward the midline. The impression was that of a horseshoe kidney with bilateral hydronephrosis and pyelonephritic infection. Patient was discharged improved October 3, 1929, but was advised to return to the clinic for further cystoscopical treatment with dilatation of the ureters and kidney pelvis lavage.

Case xvii. A. Z., female, aged forty, housewife, referred to Arthritis Clinic of Hospital for Ruptured and Crippled of New York on April 1, 1927, under the care of Dr. G. C. Snyder, complaining of "chronic arthritis" of more than four years' duration. Patient is married, has 2 boys and 2 girls all living and well. She states that she has been treated by numerous doctors and has been receiving treatment in various hospitals for her arthritis condition, also that the baking and massage have made her worse and brought no relief to the intermittent pain across her back. She is inclined to be chronically constipated, for which condition she has been receiving frequent enemas and high colonic irrigations. Otherwise her general condition is good. As she complained of pain across her back and sometimes in the left lower quadrant and umbilical region, she was referred to the Urological Department of the same Hospital. Her chief complaint at that time was of slight frequency of urination and nocturia with pain in the middle of the abdomen and radiating to both lumbar regions. She also has pain across her back and in the spinal column, which sometimes interferes with her breathing, and she is easily tired on working or standing. She states she has been suffering with arthritis and chronic constipation for many years for which she has been taking cathartics, enemas and rectal douches. She has also been complaining of occasional attacks of cystitis. The urine is hazy and contains microscopic pus. On May 9, 1927, cystoscopy revealed a normal bladder. The ureters were catheterized without difficulty, and there was good renal function on both sides. Roentgenographical examination revealed no shadow of stone anywhere in the urinary tract, but showed a left kidney shadow of large size and very low in position, also a few shadows in the bony pelvis, apparently phleboliths. The left pyelogram revealed rotation of the kidney pelvis with a slight degree of hydronephrosis, the lower pole extending beyond the midline and giving the impression of horseshoe kidney with infection on the left pelvis. Later, on June 24, 1927, a pyelogram of the right side revealed rotated kidney, with an unusual pelvis and some excavation of the middle calices which pointed inward. The ureterograms were negative, except that the course of the ureters

alongside of the spinal column gave the impression of a "flower vase" which appears to be peculiar to the ureters in cases of horseshoe kidney. The renal function was not particularly diminished on either side, but in view of the presence of pus cells and red cells in the catheter specimen, the patient was advised to have routine cystoscopic treatment with dilatation of the ureters and kidney pelvis lavage in order to relieve infection and secure better drainage, which was accordingly carried out on several occasions. The result was gratifying, although the patient still complains from time to time of her horseshoe kidney symptoms but has not been able to return to the clinic for further treatments, for extraneous reasons.

Case xviii. W. S. male, Italian, aged thirty-eight, history No. 296,876, came to the admitting room of the Urological Department of the New York Hospital on Jan. 6, 1931, complaining of pain in the bladder region and in the epigastrium, radiating across the back and particularly to the right lumbar region. Family history irrelevant. Patient has been suffering for several years with dysuria, frequency and some bladder symptoms; also with gastric trouble and chronic constipation for several years. He denies venereal disease. On physical examination the abdomen was rigid and contracted but on deep palpation the kidneys were easily palpable and enlarged. There was also tenderness in the suprapubic region. The urine had been hazy for some time and apparently contained pus. Blood pressure was normal and Wassermann test negative. Cystoscopy January 7, 1931, revealed a much congested mucosa and bulbous edema. Around the ureteral orifices and floor of the trigone, lying at the fundus of the bladder, was a stone about the size of the terminal phalanx of the fifth finger. Both ureters were catherized without difficulty and revealed diminished function in regard to urea excretion and phenolsulphonephthalein elimination. Microscopical examination of the sediment showed pus and blood cells coming from both sides. The roentgen examination disclosed the presence of stone in the bladder, and there was also a shadow about the size of a large olive over the transverse process of the third lumbar vertebra on the left side, which moved considerably in the various pictures and was apparently a calcified lymph-gland. The shadow of the kidney was larger than usual and the bilateral pyelogram revealed rotation of the pelves with the lower calices pointing inward toward the midline, thus indicating the presence of a horseshoe kidney. In this case the stone was crushed and removed from the bladder with the Lowsley rongeur. Patient has been receiving urological treatment with dilatation of ureters and kidney pelvis irrigations. Hence no surgical intervention has been considered.

Case xix. N. S. male, aged thirty-six, history No. 177,402, came to the Urological Clinic of the New York Hospital on July 17, 1930, complaining chiefly of burning on urination, frequency, pain in the upper abdomen, particularly in the umbilical region. The urine at times has been cloudy and he has been receiving medical treatment by a private doctor on various occasions, but without definite relief. He has also been suffering with gastrointestinal disorders and chronic constipation for many years. About twelve years ago he had an attack of Neisser infection, since which time he has not had any urethral discharge. However, the urine has been cloudy and the symptoms have been aggravated in the last two years. Patient had various kinds of medical examinations and treatments by various doctors and had been cystoscoped elsewhere. He stated that guinea-pig examination of the urine had been negative, but a culture of the urine had disclosed the presence of Bacillus coli communis. However, according to his statement, no one knew what was the cause of his trouble. On physical examination patient was well nourished and on deep palpation of the abdomen the kidneys appeared to be enlarged and tender. He was cystoscoped July 20, 1930, and the bladder mucosa was found to be

red and congested throughout but no evidence of pathology found in the urinary bladder. The ureters were catheterized without difficulty and the specimen from both sides was cloudy, with microscopic pyuria and hematuria. The function was slightly diminished, but urea excretion was good and phenolsulphonephthalein appeared in five minutes on each side. The roentgen examination revealed no shadow indicative of stone in the urinary tract, and the kidney shadows were indefinitely made out, but were low in position. The bilateral pyelogram revealed dilatation of both kidney pelves with slight degree of hydronephrosis. Both pelves were rotated and the lower calices turned inward toward the vertebral column, indicating the presence of a horseshoe kidney. Patient has been coming to the clinic for cystoscopic treatments with dilatations of ureters and kidney pelvis lavage. While he has improved his symptoms have not cleared up and he is still complaining of the horseshoe kidney syndrome.

Cases of Horseshoe Kidney Diagnosed at Operation

CASE XX. M. F., male, aged fifty-six, history No. 280,898, admitted into the medical ward of the New York Hospital July 21, 1928, complaining of indefinite pain in the umbilical region and lower abdomen with loss of weight, progressive weakness and a history of chronic constipation.

On physical examination the abdomen was tender and an indefinite tumor mass about the right lower quadrant was made out, for which an exploratory laparotomy was recommended. At operation a retroperitoneal fused kidney of the horseshoe type was found, together with chronic appendicitis. Appendectomy was done and the diagnosis after operation was that of a horseshoe kidney plus chronic appendix. The patient made an uneventful recovery and left hospital "improved."

CASE XXI. C. M., female, aged thirty-two, history No. 39,713, admitted to the medical service of the New York Hospital May 8, 1910 with symptoms of pain in epigastrium and a history of stomach trouble after eating. The urine was apparently clear. On physical examination there was slight tenderness in the abdomen, particularly at McBurney's point. In the course of an operation for chronic appendicitis a fused kidney of the horseshoe type was discovered. The patient had an eventful recovery from the appendectomy and left the hospital apparently improved.

Cases of Horseshoe Kidney Found at Post Mortem

CASE XXII. P. W., male, aged sixty-six, admitted to the Urological Department of the New York Hospital April 3, 1923, complaining of inability to urinate and pain over bladder and umbilical region. He had been tapped twice elsewhere with temporary relief but came to the hospital suffering with complete retention after having used a ureteral catheter for more than five weeks. On examination, a scar for perineal operation was noticed. There were moderate hemorrhoids and the prostate was enlarged to about twice the usual size and of leathery consistency. On account of the irritation and inability to tolerate an indwelling catheter a suprapubic cystotomy for drainage was done April 6 under local anesthesia. Patient became very sick and his renal function alarming. On May 7 the blood urea nitrogen was 34.27 and on May 8 he died in a uremic coma. The clinical diagnosis was uremia, renal failure and chronic endocarditis, complicated by enlargement of the prostate.

Autopsy No. 5732. Anatomical Diagnosis: Acute cystitis, chronic endocarditis, hypertrophy of prostate, chronic myocarditis, right hydrocele and infected horseshoe kidney. The direct cause of death, while undetermined, was apparently chronic endo-

carditis due probably to the horseshoe kidney disease. Pathological findings and type of lesion: The kidney is of the horseshoe type united by an isthmus which runs across the lower poles and in front of the great vessels. The organ weighs 280 gm. The ureters and

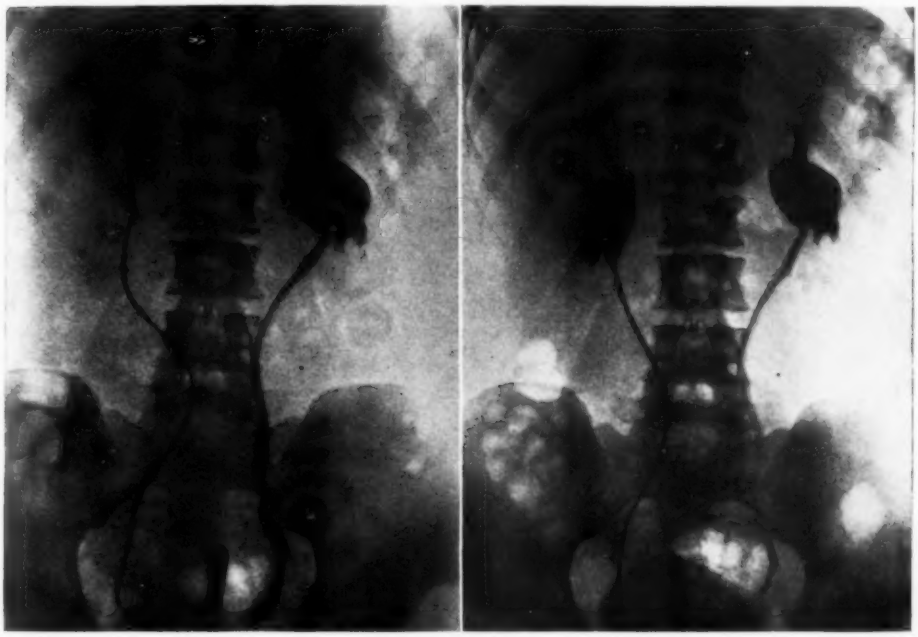

FIG. 51. FIG. 52.

FIG. 51. Left pyeloureterogram revealing marked rotation and inversion of the pelvis with the upper and lower calices pointing inward, at first giving the erroneous impression of horseshoe kidney. However, the outline of the lower pole is plainly visible and in addition the delineation of the psoas muscle can also be seen.

FIG. 52. Bilateral pyelogram of the same case, to illustrate the necessity of making bilateral pyelograms in order to rule out anomalies of rotation which are not horseshoe kidney. The pyelogram of the opposite side shows no anomaly in shape or position, and the clear outline of the normally placed pelvis and lower pole of the organ excludes the diagnosis of horseshoe kidney.

pelves lie anterior to the kidney parenchyma and are divided in such a manner that there is practically no renal pelvis. This division of the ureters corresponds to the somewhat indefinite division of the fused kidney into four organs, which are suggestively outlined by lobulations. The vessels enter the horseshoe kidney at a number of definite points along the superior border of the fused organ: the position of the abnormal organ is rather low in the lumboiliac pelvis, so that the upper poles are not in close contact with the adrenals. Sections reveal preservation of normal line markings. However, microscopical examination of the kidney tissue shows that the tubular epithelium and also the glomeruli are undergoing fairly well marked degeneration. There appears to be slight increase in the interstitial connective tissue and further degeneration and changes of chronic nephritis.

CASE XXIII. A. M. W., female, aged fifty-two, history No. 289,909, admitted into the medical ward of the New York Hospital Nov. 23, 1929. The clinical diagnosis was per-

forated gastric ulcer, gelatinous carcinoma of stomach, secondary anemia. Patient died Jan. 29, 1930.

Autopsy No. 6909. *Anatomical Diagnosis:* Carcinoma of the stomach, gelatinous ulceration of carcinoma; hourglass constriction of stomach. Blood in intestinal canal. Generalized edema. Moderate dilatation of heart. Hemorrhage through gastrointestinal tract. Infected horseshoe kidney. Direct cause of death: Carcinoma of stomach. (Horseshoe kidney?)

Patbological Findings and Type of Lesions: Kidneys are fused together, making a horseshoe kidney by the union of an isthmus across the vertebral column which unites both lower poles. The organ weighs 225 gm. The structure is crescent shaped. Capsules strip rather readily and the organ is rather light in color but has a smooth surface. On incision the markings are fairly regular; each half of the organ is drained by a single ureter which is attached to the anterior pelvis. The isthmus of the fused organ is made of kidney parenchyma. Microscopical findings show the tubules to be rather dilated and the glomeruli undergoing degenerative changes as in the characteristic lesions of nephritis.

Case xxiv. P. M., male, aged thirty-five, history No. 288,262, admitted into the medical division of the New York Hospital Aug. 21, 1929.

Clinical Diagnosis: Retroperitoneal lymphosarcoma.

Date of deatb: Sept. 21, 1929.

Autopsy No. 6834. *Anatomical Diagnosis:* Retroperitoneal lymphosarcoma with extension to stomach, spleen and mediastinum, and with ulceration into the stomach. Generalized arteriosclerosis. Dilatation of heart. Horseshoe kidney with double pelves and double ureters on left side. Direct cause of death: Retroperitoneal lymphosarcoma with many metastases and marked emaciation. (Horseshoe kidney?)

Patbological Findings and Type of Lesions: Kidneys are connected across the midline by the lower poles and in front of the great vessels, giving the horseshoe arrangement. The left kidney has a double pelvis and double ureter, which opens into the left side of the apparently normal bladder. The ureters and pelves are situated anterior to the kidney substance; otherwise the kidney tissue and ureters are not unusual, except for a moderate dilatation of the ureters and calices. The kidney parenchyma appears normal. Microscopically one section of kidney shows granular degeneration of the parenchyma and edema of the glomeruli. In another section there is a circumscribed mass of lymphocytes and polymorphonuclears. The glomeruli in this section show advanced hyaline degeneration and other changes that suggest the presence of chronic interstitial nephritis.

Case xxv. A. M., female, aged fifty, hospital No. 288,691, admitted to the New York Hospital Sept. 16, 1929.

Clinical Diagnosis: Aneurysm of arch of aorta. Lues. Carcinoma of rectum (?). Diabetes mellitus, mild.

Date of Deatb: Sept. 30, 1929.

Autopsy No. 6838. *Anatomical Diagnosis:* Aneurysm of arch of aorta. Luetic aortitis. Carcinoma of rectum. Adherent pericarditis. Horseshoe kidney fused across the midline by the upper poles.

Direct Cause of Death: Undetermined (syphilis, toxemia, cancer, horseshoe kidney disease).

Patbological Findings and Type of Lesion: Kidneys are fused by the upper poles in a most rare and unusual type of horseshoe kidney, the right being lower than the left but otherwise fairly normal in position. The entire specimen weighs about 350 gm. The isthmus that unites these upper poles is of definite renal parenchymal tissue and the concavity opens downward. The pelves are small, the left one containing two almost

separate portions. The pelves and ureters appear to lie anteriorly to the renal vessels and to the kidney parenchyma. The kidney substance seems rather pale. The capsules strip with some difficulty and leave scars behind.

Microscopical Findings: Renal degenerative changes of tubules and glomeruli. Glomeruli are edematous in appearance while others are hyalinized as in lesions of chronic nephritis.

In Conclusion: This unusual type of horseshoe kidney is worthy of recording because, according to Papin and other writers, there have been only 13 cases of this type described in the literature.

XI. TREATMENT

In the series of horseshoe kidneys which form the basis of this presentation the treatment has necessarily been most varied, partly because of the different types of cases and partly because of the difficulty in following up out-patients. Furthermore, in some instances in which no gross concomitant pathology was present the entity of horseshoe kidney disease *per se* has not been recognized and therefore nothing more than the usual urinary antiseptics and kidney pelvis lavage has been recommended. However, in studying the management of this condition together with the etiological factors and the rôle of the anomaly as predisposing to disease and to further pathology, one must conclude that on general principles, in all cases of renal fusion accompanied by the horseshoe kidney syndrome, with or without associated pathology, the fused organ must be considered in reality as a potential surgical kidney. This study has also revealed that in the great majority of cases no relief of symptoms can be definitely obtained until the isthmus of the horseshoe renal organ has been divided by the conservative surgical procedure of a symphysiotomy operation.

It is obvious, moreover, as I have already pointed out in the chapters on etiology and anatomic structure, that the high ventral implantation of the ureters does not permit the normal drainage of the pelvis, and also that the relative fixation and tension of the organ across the midline, plus its weight and pressure upon the great abdominal vessels of the blood, nerve and lymphatic circulation, interfere with the dynamic physiologic contractions of the excretory apparatus, thus producing chronic stagnation of both the urinary and gastrointestinal tracts. Hence the great majority of patients suffering from horseshoe kidney disease do not appear to obtain permanent cure under the ordinary medical and urological treat-

ment. It appears, therefore, that in the solution of this problem the only possible avenue to permanent relief or cure must lie in a surgical approach such as is offered by division of the isthmus of the fused organ and the liberation of the ureter to provide free drainage and restoration of normal function.

As an illustration of this fact we see that in this series of 25 cases only 2 appear to have been cured, and that these are precisely the two in which heminephrectomy was carried out for a stone complicating hydropyonephrosis in one half of or on one side of the fused organ. The rest of these cases are classified as follows: Improved but still with symptoms, 10 patients; unimproved, 7 patients; died, 2 patients; (one from pneumonia complicating horseshoe kidney disease and the other from acute uremia due to the horseshoe kidney). Four other patients died from different causes, but horseshoe kidney was found in all at post mortem.

It seems, therefore, that in order to solve this clinical problem before any concomitant lesion arises and to bring permanent relief of symptoms that have already appeared, three modes of management of this condition must be considered: the medical, the urological and the surgical. These three modes may be summarized and discussed in two essential groups:

1. Acute cases of horseshoe kidney with or without associated pathology.

2. Chronic cases of horseshoe kidney disease with clinical symptoms.

1. In the group of cases of horseshoe kidney disease with acute clinical manifestations, after correct preoperative diagnosis the paramount consideration is the maintenance of urinary drainage in order to relieve infection, autointoxication and back pressure. In the majority of instances the urinary stasis produced by lack of proper drainage is the true cause of the infection and of the development of hydronephrosis, pyohydronephrosis, acute pyelitis and pyelonephritis, nephritis, perinephritis and perinephro-ureteritis which, when clinically acute, are manifested by high temperature, chills, fever, sepsis, gastrointestinal disorders, nausea, vomiting, severe pain in the epigastrium, uremic symptoms and pyuria, dysuria or hematuria, etc. When a clinical picture of this type reveals the gravity of the condition, expectant medical and urological treatment

is indicated, consisting of the administration of urinary antiseptics internally, and of forced fluid either by mouth or by rectum with enemas and high colonic irrigations, cathartics and intravenous infusion of normal saline solution, accompanied by rest in bed, heat and other common proper measures. At the same time the use of indwelling ureteral catheters is essential to secure drainage and to relieve infection. Several of the cases here reported have been treated in this way with satisfactory results, as I have described elsewhere with the report of my first case.[1]

Later on, when the patient is out of bed, he should be put on a suitable non-protein diet with appropiate medication, and should receive cystoscopic treatments at ten-day or two-week intervals in order to dilate the ureters and irrigate the kidney pelvis, using a mild antiseptic solution, such as acriflavine 1:1000, revonol dextrose 1:2000 or silver nitrate 1:1000, thus assuring the maintenance of perfect drainage and preventing the development of infection or formation of stone or further pathology. The treatment, in short, is that of an ordinary case of pyelitis or pyelonephritis.

2. While patients suffering with acute horseshoe kidney may improve under this treatment, it has been observed that in the great majority of cases that have been traced over a long period of time, as in this series, they are bound to relapse and to have frequent attacks of their trouble. The horseshoe syndrome persists with its abdominal pain, its urinary symptoms, its gastrointestinal disorders, and its habitual or usual chronic constipation; the urine is hazy or cloudy from time to time and contains pus and blood cells and albumin, a certain degree of nephritis is present and the individual almost invariably becomes incapacitated from horseshoe kidney disease. In this group of chronic cases, therefore, after palliative treatment has been exhausted, the symphysiotomy operation, to divide and separate the isthmus of the fused renal mass, should constitute the most correct and final indication for assuring a curative prognosis.

Martinow, on March 9, 1909, was the first to divide the isthmus in order to separate the two fused kidneys. But it appears that Rovsing on June 17, 1910, was the first to describe in full the

[1] Gutierrez, R. The value of indwelling ureteral catheters in urinary surgery. *Surg. Gynec. Obst.*, 50: 441–454, 1930.

technique of the new operation that bears his name, reporting a successful case and pointing out the advantages of the method even in the normal horseshoe kidney. He recommended the transperitoneal route of approach by the midline incision of laparotomy, but while the method was practiced by Kroisz, Brougersma, Van Houtum, Kidd and others it has never gained popularity for the reason that practically all these kidneys are infected; hence, the great damage inflicted in the contamination of peritoneum is obvious.

It was Papin who, on October 22, 1922, introduced a modified technique using the Pian transverse lumbo-anterior incision for an extraperitoneal approach to separate the isthmus of the fused organ with satisfactory results. According to this author and the tabulated study of cases collected from the literature by Eisendrath, Phifer and Culver as well as other authors mentioned previously, it appears that all those patients who submitted to the division of the isthmus, or renal symphysiotomy operation, have had complete relief of pain and symptoms. In dividing the isthmus, as Papin has pointed out, it is advisable to do a nephropexy or suspension of half of the organ on the side at which the operation has been performed, since this allows the kidney to swing back into the lumbar fossa where it normally belongs and at the same time permits the other half on the opposite side to move away from its unique position upon the solar plexus and the great abdominal vessels, thus ultimately serving to bring about a permanent cure. In addition care should be taken of the aberrant renal and pyelic vessels, as well as of the adhesive bands of tissue which interfere with free ureteral drainage. The kidney should be placed in such a position that the pelvis and inferior calices will secure a perfect drainage. The ureter should be liberated from the isthmus and from its renal surface and peritoneal attachments in order to restore the physiological mechanism of its function. With a good preoperative diagnosis and a precise technique, in order to control any oozing or bleeding from the divided renal isthmus, these operations can be carried out with safety and without great difficulty. They result in permanent cure, as in the two cases of heminephrectomy here reported in which the technique was more or less that of an ordinary nephrectomy or partial heminephrectomy.

Other operations may be required in the surgical management of horseshoe kidney, particularly when the presence of associated

pathology demands them and obviously when the other half of the organ has enough function to maintain life. In this series of cases, two patients were heminephrectomized successfully for hydropyonephrosis complicating stone in one-half of the organ, with curative results. Two other patients were operated upon for the removal of renal stone by an anterior pyelotomy. One cystostomy was done and one litholapaxy, and in 3 cases stone was removed from the ureters and bladder by cystoscopic and ureteral manipulations. Although many of these patients have improved considerably under medical and urological treatment, some of them who still have clinical symptoms and in whom a surgical procedure was planned have not been traced or have not come back to the clinic, while others have refused the operation. The writer, however, is firmly convinced of the beneficial results of the symphysiotomy procedure and believes that it is properly indicated in this type of cases of symmetric horseshoe renal fusion. He expects in the near future to be able to report an improved technique and the results obtained from the same.

XII. SUMMARY

In summing up the clinical management of horseshoe kidney it is obvious that accuracy in establishing a correct diagnosis and the proper indications for medical, urological and surgical treatment are the paramount considerations for the assurance of a sound prognosis.

Horseshoe kidney disease as a new clinical entity can be easily recognized both clinically and radio-urographically, and whenever the horseshoe syndrome of nephralgia and other clinical manifestations is suggestively present, the urographic examination will confirm and verify the final diagnosis.

Bilateral instrumental pyelograms whenever possible (taken at different sittings if necessary) or intravenous uroselectan pyelograms are absolutely necessary, not only for the verification of the diagnosis but also in order to exclude the possibilities of other abnormalities, since the lack of, or the incomplete, rotation and inward inversion of one pelvis seen in a unilateral pyelogram, does not always mean the presence of horseshoe kidney. We must also exclude the embryonic type of renal pelvis and the unusually placed

pelvis due to an ectopic kidney or dystopic asymmetric renal fusion, or to a certain degree of nephroptosis, or to torsion or renal misplacements resulting from trauma or intraperitoneal or extraperitoneal neoplasma. To this end the routine procedure of measuring the basal angle in the horseshoe triangle as here proposed by the author will serve as a means of eliminating error and clarifying the final diagnosis.

Nevertheless, it is essential that the diagnosis shall correspond with the clinical condition of the patient, and to be complete it should be based in the following roentgenographic and urographic data: (1) The visualization of the outline and position of the kidneys; (2) the possible delineation of the isthmus; (3) renal shadows of calculi close to the vertebral column or overlapping it; (4) in a bilateral pyelogram, the abnormal rotation of the pelves; (5) the lower calices pointing inward; (6) the "flower vase" position of the ureters; (7) the "bottle neck" shape at the ureteropelvic junction; and (8) the "pathognomonic pyelographic horseshoe triangle" with its minimum basal angle hovering around 20°. A consideration of all these points in the diagnosis will definitely reveal the presence of the clinical entity of horseshoe kidney disease.

In looking over this series of cases, one cannot fail to be struck by the fact, that, of the group of 19 patients diagnosed preoperatively, practically every one came in with an erroneous diagnosis, and 12 of this group had already been operated upon elsewhere for various abdominal conditions, before our diagnosis of horseshoe kidney was made, thus bringing out the paramount importance and necessity of a correct preoperative diagnosis.

The treatment of this condition in acute cases should be medical and urological, but later on, when the patient has recuperated from the acute symptoms and complete invalidism, and before any further pathology develops, it should always be surgical, establishing the division and separation of the isthmus of the fused organ by renal symphysiotomy. This operative procedure should be followed at the same time by a nephropexy or suspension of one half of the organ on the side where the operation has been performed. Care should also be taken to free the ureter and pelvis from bands of adhesions and aberrant blood vessels, in order to restore ureteric and pelvic dynamic physiological function and to secure a better drainage.

All in all, the results obtained in the clinical management of this series of cases have been most gratifying, particularly when urological treatment has been systematically carried out in the form of dilatation of the ureters and kidney pelvis lavage and in the acute cases when the indwelling ureteral catheter has been used, thus saving patients from uremia and death.

Of the 19 cases diagnosed preoperatively, 15 (79 per cent) were suffering with pyelitis and pyelonephritis infection due mainly to urinary stasis and lack of proper drainage, which are obviously the chief etiological factors in horseshoe kidney disease and represent the beginning of its most common complication.

XIII. Conclusions

1. Horseshoe kidney disease is physiologically, anatomically, pathologically and surgically of sufficient frequency to warrant its medical recognition as a new clinical entity of paramount importance.

2. The disease is produced mainly by the unique position of the anomalous organ in the middle of the abdomen and in the retroperitoneal space, lying where it not only makes pressure upon the aorta, vena cava, solar plexus and other anatomic structures, but also, where by its incarcerated position, it is prevented from performing its own normal physiologic function.

It is clinically characterized by the presence of the horseshoe kidney syndrome, namely, (*a*) nephralgia or pain in the middle of the abdomen referred to the epigastrium or umbilical region; (*b*) gastrointestinal disorders with a long history of marked chronic constipation, and (*c*) long-standing intermittent attacks of urinary disturbances (see Table IV of the text).

3. Every individual who is born with this type of renal fusion is potentially suffering from a certain degree of horseshoe kidney disease (chronic, acute or subacute).

4. Two types of horseshoe kidney must be considered, the symmetric and the asymmetric. In the symmetric type, the fusion of the two organs is made by the union of the lower or the upper poles by an isthmus of renal parenchyma, with a concavity facing upward or downward, and with the connecting isthmus lying in the midline across the vertebral column, in front of the great abdominal

vessels and adherent to the parietal layer of the peritoneum. This anomaly of renal fusion constitutes the typical anatomic structure which is characteristic of the true type of horseshoe kidney disease. In the asymmetric type the two kidneys are united in various other abnormal forms and occupy an ectopic position. This very unusual renal anomaly, which as a rule is placed low down in the bony pelvis or at one side of the spinal column, is in reality not of the true horseshoe type, and will be discussed later in another paper. Of the first type of symmetric renal fusion or renal symphysis, 25 cases are here reported.

5. The etiological factors in the fusion of the two kidneys, while undetermined, appear to date from the first weeks of embryonic life when the two kidney blastemata are imbedded and placed together topographically within the preaortic mesodermal membrane of the mesonephros, whereupon, probably for lack of migration and rotation, the two organs unite to constitute the semicircular horseshoe renal mass before they have a chance to ascend into the normal position in the lumbar fossae of the adult.

6. All of the cases in this series were found to have various degrees of pathology. Twelve of the patients had been operated upon elsewhere for various abdominal conditions under erroneous diagnoses, without obtaining symptomatic relief and before our diagnosis of horseshoe kidney was made. Two deaths occurred in this series, one from uremia and one from a pneumonia complication, but both probably as the result of horseshoe kidney disease of long standing. Four other deaths have been reported, of patients in whom horseshoe kidney was found at autopsy, and in whom it can be fairly assumed that the kidney anomaly played an important part in the concomitant pathology and the causation of death. In only 1 case, found at necropsy, were the two halves of the organ united by the upper pole, which constitutes a very rare instance.

7. Of the 25 cases here reported, 19 were diagnosed preoperatively by urologic and radio-urographic examination, 2 were discovered at operation and 4 at autopsy. Of the 19 cases that received urologic and urographic examination, the diagnosis was correctly made in all, leading to the conclusion that when the patients are submitted to a complete and accurate examination the diagnosis can be established in 100 per cent of the cases.

8. Most of the pathology found is due to the high implantation of the ureters and to the ventral position and inward rotation of the pelves with the lower calices extending transversely into the renal isthmus, a condition which is obviously responsible for the lack of normal drainage and which leads ultimately to urinary stasis, thereby causing continuous irritation and infection, with histopathological evidence of chronic pyelitis and pyelonephritis, nephritis and perinephritis and in some instances the formation of hydronephrosis, pyonephrosis or even fatal uremia (see Tables I, II and III).

9. The weight, pressure and relative fixation of the incarcerated organ, plus the continuous tension caused by the intra-abdominal pressure, interfere with the dynamic physiologic function of the entire excretory apparatus and become responsible for the chronicity or exacerbation of all the abdominal symptoms and for the chronic stagnation of the intestinal as well as of the urinary tract.

10. The diagnosis of this condition must be based in the first place on the suggestive signs and symptoms and should then be confirmed by both roentgenographic and urographic examination, with the main dependence placed on the bilateral pyelogram, obtained either by instrumental pyelography or by intravenous injection of uroselectan.

11. Other important points in the diagnosis are the comparative estimation of renal function and the determination of concomitant or associated pathological lesions, in order to establish the appropiate operative treatment.

12. The graphic points for establishing a correct diagnosis of horseshoe kidney are as follows: (1) The visualization and perfect outline of the position of the kidneys; (2) the possible delineation of the isthmus by the roentgen ray; (3) renal shadows of calculi close to the vertebral column or overlapping it; (4) in a bilateral pyelogram, the abnormal rotation of the pelves; (5) the lower calices pointing inward and toward the midline; (6) the "flower vase" position of the ureters; (7) the "bottle neck" shape at the ureteropelvic junction, as if the ureters were leaving the pelves from behind; (8) the "pathognomonic pyelographic horseshoe triangle," with its minimum basal angle of approximately 20° which, taken in combination with all these other points, will reveal the diagnosis of the clinical entity of horseshoe kidney disease (see Fig. 39).

13. The treatment of this condition must be considered from three different standpoints, namely (*a*) medical, (*b*) urological and (*c*) surgical.

(*a*) In the medical treatment when acute symptoms are present, rest in bed, forced fluid, urinary antiseptics, cathartics, high colonic irrigations and intravenous infusion of normal saline solutions are indicated.

(*b*) The urological treatment consists mainly in securing drainage and in relief of infection by cystoscopic treatments, kidney pelvis lavage and the method of the indwelling ureteral catheters.

(*c*) It appears that the ideal treatment for this condition, as soon as the patient is relieved from the acute symptoms, is surgical intervention. Two types of cases must be considered: (1) Cases in which some concomitant associated pathology is present, and in which some type of surgical intervention may be required as in any other pathological lesions of the kidneys. Obviously one-half of the horseshoe organ must have enough function to maintain life, particularly when heminephrectomy is the operation to be carried out. (2) Cases in which no visualized pathology is present, but still the horseshoe syndrome is clinically evident. Here renal symphysiotomy for the division of the isthmus of the fused kidney should be the operative procedure of choice, followed by routine nephropexy, nephrolysis and ureterolysis.

14. There can be no doubt that those unfortunate individuals who have been born with horseshoe renal deformities have the same claim on the corrective possibilities offered by modern surgical procedure as those suffering with any other congenital surgical malformation of the human body under the dominion of the surgeon's knife.

In view of the fact that horseshoe kidney is universally recognized as a predisposing cause of disease, giving rise to clinical symptoms, pain and suffering, and as a rule to concomitant pathology, it appears that the solution of the clinical problem of horseshoe kidney disease must be found in the extraperitoneal operation of renal symphysiotomy or symphysiectomy, whenever possible. This operation is a conservative and preventive procedure that finds its justification in the assurance it offers of a good prognosis, finally relieving symptoms and achieving permanent cure.

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(The End)

The American Journal of Surgery

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EDITORIALS

THE PASSING OF A PIONEER IN RADIOLOGY, GUIDO HOLZKNECHT

THE medical world as a whole and the radiological section in particular join in mourning the loss of Guido Holzknecht, of Vienna, whose untimely death was recorded in the newspapers of early November. Early roentgen injuries by their insidious and persistent influence finally wore out the resistance of this pioneer worker who succumbed only after numerous operations, including the amputation of both arms.

The work of Holzknecht has represented the acme of roentgenological development at all times, both in diagnosis and in therapy. Beginning in 1899 with a paper on a new radiological symptom of bronchial stenosis, the literature of roentgenology is rich in the product of this wonderful man's tireless industry, more than one hundred and twenty articles having appeared from his pen during his first ten years in addition to three books by himself and two others in association with co-workers. As early as 1901 there appeared a book on the radiological diagnosis of diseases of the chest. In 1903 he published a monograph on radiology as a specialty in medical practice. In 1908 appeared the widely read text on intra-ventricular and extra-ventricular tumors, and almost simultaneously the text on the roentgen diagnosis of the stomach. Interspersed were articles exhibiting the keenest and most ingenious efforts at solution of the problem of applying roent-

genological methods to the diagnosis and treatment of a long list of maladies from acromegaly and alopecia areata to foreign bodies. As a pioneer this versatile man attacked every problem with an energy which could not be rebuffed by any difficulty.

Because of the financial stringency attending much of his early work, Holzknecht spent an enormous amount of time at fluoroscopy, especially of the heart and great vessels, and the esophagus, stomach and intestines; and no doubt here was the cause of his martyrdom, for the injuries caused to his hands in the early work, aggravated in spite of what were considered adequate protective measures in all the later years by his continuation in fluoroscopic radiology brought about his final defeat in the painful but stubborn battle against roentgen cancer.

It would be a pity were we not to pause for careful consideration of the dangers of fluoroscopy. In this age of wide dissemination of *x*-ray equipment with the yearly addition of hundreds to the rapidly growing ranks of students of radiological diagnosis, there has arisen much misconception as to the place of fluoroscopy.

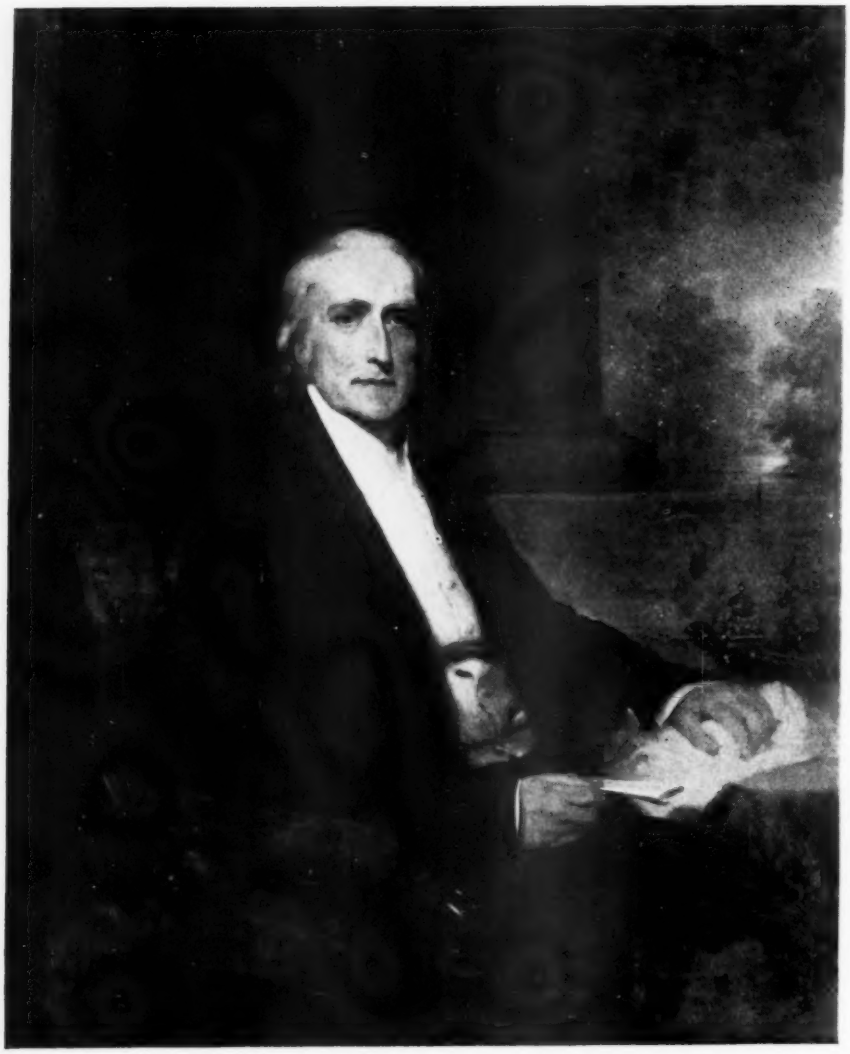
True, one can learn much by screen studies; here is not the place to elaborate on this point. But it is not a question of how much can be learned from fluoroscopic observation, rather what is the maximum degree to which screen studies can be dispensed with by substitution of radiographic studies. The screen is indispensable; we must have its benefits; but a little planning will permit its avoidance much of the time with no loss of diagnostic accuracy.

For example, in the stomach, with a satisfactory set of serial films one is usually able to be assured of the normal findings or the presence of an organic lesion, and the screen study may often be dispensed with on the basis of the film study, if the films are prepared and studied first. Screen observation is a necessity in esophageal lesions and in some intestinal studies, especially in the sigmoid and cecum. In chest cases, patients are often referred for "screen and film study" when a more reasonable request would be for a "film study and screening if indicated." It is relatively infrequent that the posteroanterior stereo and the lateral films of the thorax do not suffice without screen study. As a precaution to avoid recalling occasional cases, the patient should not be allowed to leave the examining office until the roentgenologist sees the wet films and decides whether additional screen observation is needed.

From the economical viewpoint of consumption of *x*-ray materials, it is true that fluoroscopy is much cheaper than film studies and in this day of earnest effort to reduce the cost of medical service in the interests of those in modest financial circumstances it may superficially appear to be the desirable method of *x*-ray study; but the keenest eye will never begin to see in a brief study of the relatively obscure field of the most brilliantly lighted screen the greater wealth of detail shown on the permanent film record which is susceptible of repeated and prolonged study; and the economical advantage should not weigh against the apparently unavoidable insidious damage suffered to some degree by every radiologist who does fluoroscopy with the probability of the later development of chronic skin lesions on the hands, often not appearing for eight or ten years, entailing countless hours of suffering, maiming operations, to say nothing of other vital damages and in many instances final martyrdom.

Holzknecht, we cherish your memory as an indefatigable investigator, patient and able teacher, and respected friend.

James T. Case.



PHILIP SYNG PHYSICK

[1768-1837]

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AMERICAN PHYSICIANS

PHILIP SYNG PHYSICK

"THE Father of American Surgery," Philip Syng Physick, was born in Philadelphia on the 7th of July, 1768.

His father, an Englishman, held office in the Colonial government as Keeper of its Great Seal, and after the Revolution he became agent of the Penn family, which brought him great riches.

As the Physicks lived in the country, seven miles out of Philadelphia, Philip was introduced as a boarder in the family of Mr. John Todd, father-in-law of the lady who, as Widow Todd, became the wife of James Madison, afterwards President of the United States. Philip was placed under the care of the historian, Robert Proud. From the academy he was transferred to the classical department of the University of Pennsylvania, where in 1785 he took his A.B. degree.

After a month's rest Physick entered the office of Dr. Adam Kuhn, then Professor of Materia Medica and Botany in the Philadelphia College of Medicine. He remained with Dr. Kuhn three and a half years. He did not take his degree but went abroad (1789) and studied under John Hunter. He became a member of Hunter's family. He was selected as house-surgeon to St. George's Hospital for one year. Physick remained under Mr. Hunter's care for two years and four months. Hunter invited Physick to take up his residence with him and to share his professional burdens, what most people of that time would have considered an enticing opportunity. However, Physick went to Edinburgh, after receiving his license from the Royal College of Surgeons (1791), and received his medical degree in May, 1792. The following September finds him back in Philadelphia. At first the going was hard and he had few, if any, patients.

In 1794 he became surgeon to the Pennsylvania Hospital, and professor of Surgery in the University of Pennsylvania (1805–18). With all his brilliancy and training he wrote nothing of great note. He introduced absorbable kid and buckskin ligatures, the use of the seton in ununited fracture, an operation for artificial anus, rest in hip-joint disease, and the invention of the tonsillotome. It is said he was the first to describe diverticula of the rectum, and the first American to wash out the stomach in cases of poisoning.

His reputation spread to all parts of his country and abroad. He had one of the largest and most remunerative surgical practices of his day.

Philip Syng Physick expired on December 15, 1837.

T. S. W.

[From Fernelius' Universa Medicina, Geneva, 1679.]

BOOKSHELF BROWSING

WHAT EXPERIMENTAL ANIMALS HAVE CONTRIBUTED TO OUR CONTROL OF TUBERCULOSIS*

J. A. MYERS, M.D.

MINNEAPOLIS, MINN.

IS Tuberculosis Communicable? This is a question that was debated for centuries. From the writings of the Greeks we learn that at some time earlier consumption was believed to be contagious, but that this belief had been abandoned. The Greeks apparently believed consumption to be a universal disease due to heredity and, therefore, that nothing could be done to prevent it. The Romans, however, did believe somewhat in the contagious nature of tuberculosis. Galen (131–201 A.D.) said: "Besides there is danger in being extremely intimate, especially in the conjugal relationship, with those who suffer from consumption and with all who give off putrid matter to such a degree that the room in which they sleep has a heavy odor."

Franciscus Sylvius (1614–1672) wrote: "The air expired by consumptives having been brought close to the mouth and nose, is drawn in and in this way offensive and irritating emanations are continuously carried from the affected party to others, especially relatives, and when these are finally infected with the same poison they also fall into phthisis."

A law which was passed in Spain in 1751 indicates that the contagiousness of consumption was taken very seriously. One of the regulations required the reporting of the disease by physicians, and provided severe penalities for failure to report.

In Italy a similar law was enacted in 1782. This provided further for thorough cleansing of premises and the destruction of clothing after a death from consumption, and the replastering of houses, the segregation of hospital linens, and other details growing out of the fear of contagion.

This law in Italy aroused much antagonism. In 1777, an article was published opposing the doctrine of contagiousness of consumption and trying "to expel from the public mind the radical error of this doctrine through which so many unfortunate sick people have been deprived of necessary aid and on account of which they have been abandoned in their distress and martyrdom."

By 1809 there was so much opposition that the chief magistrate of Naples consulted the medical faculty regarding the wisdom of keeping it on the statute books. There was a great diversity of opinion and

* From the Department of Preventive Medicine, University of Minnesota.

This is the first of a series of articles on THE VALUE OF ANIMAL EXPERIMENTATION IN MEDICAL PROGRESS. The next article will appear in an early issue.

the majority of the faculty were opposed to the law. However, the strongest men were in favor of it and the law continued to be at least partly in force, while the hostility toward it increased. In fact, Paganini, the famous violinist, while suffering from consumption in 1819, was thrown into the street from a hotel in Naples because the landlord so strongly believed in the contagiousness of the disease. A friend of Paganini's, however, passing by, saw the episode and not being convinced of the contagiousness of consumption stepped into the hotel and gave the landlord a sound thrashing. This friend then took Paganini and his equipment to a place where he received excellent care.

It is apparent, therefore, that for centuries the contagiousness of consumption was purely a matter of opinion. No scientific evidence was available. Many were suffering terribly because of the attitude of those who believed strongly in the contagiousness of the disease. At the same time, others with the disease were spreading it because of the protection from those who believed that the disease was not contagious. Turmoil reigned because of the lack of knowledge, knowledge which could be obtained in one way only, that is, by experimental methods.

HUMAN AND ANIMAL TUBERCULOSIS

It was not only human beings who were suffering from tuberculosis; animals were also suffering and dying. In fact, the Greeks and Romans had observed that consumption attacked animals, although they did not understand the relation between the disease in animals and that in man. Aristotle (384–322 B.C.) called the disease scrofula. In certain Hebrew books we find descriptions of the disease and provisions for excluding unhealthy meats from the diet. Agostino Bruno, who practiced medicine near Naples, believed consumption was contagious in animals. Gradually the idea arose that the disease in man and in animals might be the same. If it could be transmitted from one to another much might be learned about it.

In 1789, Kortum injected pus from a scrofulous patient into the neck of a boy. However, no disease was produced in the boy. A little later one investigator inoculated dogs with pus from scrofulous patients, and another one inoculated pigs; but in neither case did the animals develop the disease. This was perhaps the beginning of such work, though the technique was poor and the material inoculated was not the best for the purpose.

In 1843 Hermann Klencke (1813–1881) stated that he had been able to produce tuberculosis in rabbits by inoculating them with tuberculous material; and in 1846 he declared that tuberculosis could be transmitted by cow's milk.

SYSTEMATIC EXPERIMENTATION

In 1867, Jean-Antoine Villemin (1827–1892) published a book in which he gave the results of his extensive studies on tuberculosis during the previous years. This advanced our knowledge so much that it entitles its author's name to be placed on the walls of immortal fame. His work paved the way and it is almost unbelievable how the death rate and the incidence of tuberculosis have fallen in the brief time since Villemin's contribution was made. Into small wounds which he made behind the ears of rabbits, Villemin inserted fragments of tubercle taken from the bodies of people who had died of the disease. He later killed these animals, and in the majority found evidence of tuberculosis. In every instance a control animal was kept and killed at the same time as the inoculated animal; this rabbit was found to be free from tuberculosis. Next he transmitted it from rabbit to rabbit. He also produced the disease by inoculating tubercle and even sputum of man into guinea pigs, sheep and other animals. Thus the problem was solved. *Tuberculosis had been proved to be a contagious disease*, both for man and animal, yet many people long refused to accept the definitely established fact.

Although the work in the past had been splendidly done, particularly that of Villemin, it took something that could be visualized to convince many that the disease is in fact contagious. In 1877, Julius Cohnheim (1839–1884) and Salomonson carried out some ingenious experiments to prove beyond doubt that tuberculosis is contagious. They inoculated tuberculous material into the anterior chamber of the animal's eye, and there, through the clear cornea, they could see the development of tubercles from day to day. This work was confirmed by others in the next four or five years and thus it became well established that *there is something in tuberculous material which is capable of growing when inoculated into the bodies of healthy animals.* What could this be? It must be something extremely small because inoculation of very minute particles of tuberculous material produced disease.

MAKING THE CONTAGION VISIBLE

The microscope had been developed and at that time so well perfected that objects could be magnified several hundred times. It was this instrument which made the next step possible. Already it had helped to show that anthrax, relapsing fever, leprosy, typhoid fever, chicken cholera and other diseases were caused by minute living organisms.

Robert Koch (1843–1910), a country practitioner, took tuberculous material from the lungs of animals, properly prepared it, placed it under the microscope and saw large numbers of very small rod-shaped organisms. He felt that these must be the cause of tuberculosis but he did not have sufficient proof. He next applied various dyes to them and finally found they had the peculiar quality of retaining acid dyes when other organisms in the same field yielded up the dyes under a certain chemical treatment. He noticed that those organisms which retained the dyes were constantly present in tuberculosis and appeared to be the same small, rod-shaped structures that he could see without the use of dyes. His next step was to isolate this microorganism and grow it in pure culture. Previous to his time no nutrient had been found suitable for growing this particular kind of microorganism. Koch therefore searched for some time to find a medium upon which it would grow in pure culture. When he had one which he believed would be satisfactory, he placed upon it material from tuberculous processes, then placed it in an incubator with a temperature closely approximating that of the human body.

Koch was patient, he watched these preparations day after day. As time passed, he began to see developing on the culture media small whitish points. Taking a little of this material and placing it under the microscope, he brought to his vision the small rod-shaped microorganism he had seen from the original tuberculous material. Staining these organisms, he found that they had the same characteristics as those observed in the original tuberculous material. Thus he had grown them in pure culture; but how was he to prove to the world that these actually are the cause of tuberculosis? There could be just one way, and that was to inoculate this pure culture which he had grown artificially into the bodies of animals and see what happened. He then inoculated a series of animals and found tuberculosis developed in their bodies. Without the use of these animals the world would still be in darkness as to the true cause of tuberculosis, and the fight against the disease would in all probability be a losing one as it had been in all the past history of the world, instead of a winning one as it is at present.

VALUE IN DIAGNOSIS

The works of Klencke, Villemin, Cohnhein and Koch proved to be great steps in detecting disease earlier than it had ever been detected before, thus materially increasing the chances of recovery of people suffering from tuberculosis. In many cases it is not easy to find germs by the usual methods and resort to animal

inoculation makes diagnosis possible weeks before it could otherwise be made. In the early stages of the disease and before the tissues are badly broken down not many germs are being cast into the sputum. Moreover, the microscopic examination is made with an extremely small amount of sputum and the germs may therefore be entirely missed. If, however, a quantity of sputum or other suspected material is inoculated into the bodies of animals, even though only a few germs be present, they will multiply and cause disease in the animals' bodies, thus making it possible to determine the presence of disease. If germs are not present the animal is in no way injured or harmed, but if they are present the animal loses its life but human life is often saved. The following case illustrates this point.

A young man reported because he had recently expectorated some blood. Physical and *x*-ray examinations revealed an area of disease but it could not be determined with a high degree of certainty whether this disease was due to tuberculosis. The examination of the sputum by the usual method showed no evidence of germs of tuberculosis. It was important to know in this case because the treatment to be administered would depend upon whether or not the disease was caused by these germs. Some of the sputum was inoculated into the body of a guinea pig. In approximately two weeks a test was applied to this animal's skin; this showed that it had developed tuberculosis. A little later the animal was chloroformed and a post-mortem examination showed that it had unmistakable tuberculosis. This finding was sufficient and drastic treatment was quickly instituted. Many years have passed although the treatment is still being employed; this man was restored to good health and has had a splendid working capacity for a long time. The life of an animal was lost but the life of a man was saved.

Another need for definite knowledge as to whether or not tuberculosis exists in certain cases comes from our desire to protect other human beings from exposure to those who are capable of distributing the germs of tuberculosis. For example, a mother reported for an examination because she had felt a little below par for some time. She had a slight cough. Ordinary methods of examination revealed no germs in the sputum. This mother was greatly worried about her children becoming infected. Her mind was much relieved when germs were not found by the usual method, but inoculation of sputum into a guinea pig proved beyond doubt that she was casting tuberculosis germs from her body. Knowing this, she immediately took measures to prevent the spread of the germs to her children, and at the same time to take the treatment which would help her overcome the disease in the shortest possible time.

There can be no doubt that by this simple procedure of animal inoculation thousands of human lives have been saved and extended, and that many thousands of others have been made happy because disease was prevented from entering their bodies. This is not a matter of opinion, it is a scientifically established fact.

Is Tuberculosis Curable? For centuries tuberculosis was held to be fatal in every case, because of general ignorance of the facts. Even today this idea is widely prevalent. We often hear it said, "once tuberculous, always tuberculous." This is not encouraging for the patient. Moreover, it is untrue. No one could confidently oppose the statement, however, until it had been scientifically proved untrue. Physicians had observed the complete recovery of people whom they believed to be tuberculous. Pathologists, at the post-mortem table, had seen many bodies containing old tuberculous processes that seemed well healed. But nothing except animal inoculation and careful study of the diseased tissue from day to day could prove how the disease healed.

Gardner of Saranac Lake inoculated guinea pigs with germs of tuberculosis which had lost much of their virulence through long growth and special treatment. These cultures did not kill the guinea pigs although they did produce definite disease.

As the disease developed and went through its various stages, Gardner killed the animals one by one by a painless method. With a magnifying glass he located in the lungs the diseased areas, removed them, and studied them in a most detailed manner with the microscope. By this work he proved beyond doubt that *the animal's body is capable of developing definite tuberculous disease and then healing it so completely as to leave almost no trace of its former existence.* This fact well established makes it possible for the patient and those responsible for his care to take heart and look forward to the time when his disease may be completely overcome.

TYPES OF TUBERCULOSIS GERMS

There are three types of tuberculosis germs. They are the *human, bovine* or cattle, and the *avian* or bird type. The human type most commonly causes the disease in man. The bovine type is not uncommonly found as a cause of disease in man. The avian type causes disease in man very rarely.

All of these types of tubercle bacilli appear exactly the same when studied under the microscope but when inoculated into the bodies of animals each shows distinctive characteristics. For example, the human type produces serious disease when inoculated into the bodies of guinea pigs, and only very mild disease when inoculated into the bodies of rabbits. The bovine type causes very serious disease when inoculated into the bodies of rabbits, and only mild disease when inoculated into the bodies of guinea pigs. The avian type produces serious disease when inoculated into the bodies of fowls and very slight or no disease in the bodies of guinea pigs and rabbits. Animal inoculation therefore serves to differentiate the germs.

In some cases of tuberculosis in man it is very important to know which type of germ is the cause of the disease, because this materially affects the treatment as well as the ultimate outlook for the patient. In such cases it is necessary to inoculate animals and thus determine accurately the type of germ present. Again, in obscure cases such animal inoculations may lead to the detection of the disease.

For example, in a man who had been ill for some time there was evidence of disturbance in one of the kidneys. The exact nature of the trouble could not be determined. Tubercle bacilli in the urine could not be seen with the microscope. Guinea pigs were inoculated and later developed tuberculosis, thus proving that the kidney was tuberculous.

It is a well-established fact that when tuberculosis exists in one kidney the best treatment is removal of that organ, for if allowed to continue, the disease is very likely to find its way to the bladder and later to the opposite kidney, and eventually the patient's life is lost. In this case, a few pigs lost their lives, but a human life was saved.

In testing out new methods of treatment, or methods of prevention, the animal is of wonderful service. A treatment which may seem perfectly rational is best applied to animals first, in order that the effect may be thoroughly studied and well understood before it is applied to the human body and in order that the dosage may be standardized. If there is an element of danger in the proposed remedy or treatment, this will be learned. On the other hand, if it is worthless so far as the treatment of disease is concerned, this will also be learned. Many times in the history of the treatment of tuberculosis this method has been used with great saving to human beings.

Is Tuberculosis Preventable? Of course it is the prevention of tuberculosis that we are all seeking. How can the human body be rendered immune to the disease? This is a burning question at present and a good many people in various parts of the world are trying to answer it. From Paris have come reports that a method has been devised whereby the mortality of tuberculosis among infants has been reduced. These reports are from the laboratories of one of the world's out-

standing authorities on the subject. He believes if the method is so perfected that it can be applied to older children and adults the future will be bright for the prevention and eventual eradication of tuberculosis.

How was this method devised? It was through the use of experimental animals. Albert Calmette took tubercle bacilli of a certain strain and grew them artificially in incubators over long periods of time. By so doing he reduced their virulence and finally had so changed them that when they were inoculated into the animal's body they did not produce disease but did produce *tuberculin*, which he believes stimulates the formation of protective elements in the body and keeps them active and ever ready to fight virulent strains of tubercle bacilli, in case they gain entrance.

Similar work is being carried out in this country where herds of cattle are being used experimentally. These animals are well fed and kept extremely well nourished, they suffer no pain, enjoy eating like other animals, sleep and rest as other animals do, and are not being harmed; yet they are being experimented upon, and a great deal is being learned. Whether Calmette's method is of great value in preventing tuberculosis or whether it is harmful to the body should be proved through the use of experimental animals.

PNEUMOTHORAX

In recent years surgery has come to the rescue in the treatment of tuberculosis of the lungs. In fact, it has come to be one of the outstanding methods of treatment in certain types of cases. By it a diseased lung is collapsed, thus putting it at rest, and the tuberculous disease is thereby brought under control. This is not a matter of theory but of actual practice, and the results obtained fully justify the operations employed. These procedures were developed through operations performed on many animals, to determine just how much could be done with safety and what results could be obtained under different conditions. When these were determined more animals were used by surgeons in perfecting this technique, that is, in developing such skill that surgeons may quickly and safely operate on the human chest. This work with animals has made it possible to introduce in many places surgery of the chest with the least danger and with the greatest good to the patient.

TUBERCULOSIS AMONG ANIMALS

The experimental work on animals is not only of value to man but is proving of tremendous value to the various animal families themselves. The veterinarians are intensely interested in obtaining information concerning the control of tuberculosis since this disease makes such terrible inroads among animals. Careful investigation has shown that in some parts of this country a high percentage of the swine herds are infected with this disease, also that a high percentage of cattle have become infected. In fact, tuberculosis attacks nearly all animals in captivity. Experimental work which leads to more knowledge regarding the control and treatment of this disease, enables the veterinarians to prevent ravages among animals. Thus by the use of animals man has learned that:

(1) Tuberculosis is a contagious disease.

(2) Tuberculosis is caused by the tubercle bacillus.

(3) Tuberculosis can be detected by animal inoculation.

(4) Tuberculosis heals well under proper conditions.

(5) Tuberculosis in some forms may be treated successfully by surgery.

(6) Tuberculosis is preventable.

To learn these facts and to have them scientifically established has required the use of many experimental animals. To the human family this has meant the saving of many thousands of lives, to say nothing of the suffering and sorrow it has prevented.

MEASURABLE GAINS

About 1843 when Klencke proved that tuberculosis is communicable, the death rate from tuberculosis was approximately 450 for every 100,000 people living. Now the rate is approximately 88 for every 100,000 people living and we may expect that this rate will be still further reduced; but it will require the use of more animals to yield new facts about the disease and its treatment before it is reduced to the humanly attainable minimum.

EXPLOITING ANIMALS

Most of the animals which man raises are raised for a purpose. Swine are raised in large numbers only to be driven to the slaughter houses, to be stuck with a huge knife and the life blood allowed to flow away. The carcasses are then prepared and placed upon the market to supply man's need for food. Cattle are raised in large numbers to be shipped to the slaughter houses, struck with a sledge hammer and the carcasses then placed on the market and sold for food. In both cases lives of animals are taken prematurely; yet they were raised by man for the purpose of supplying food.

Animals such as guinea pigs and rabbits used in the experimental study of tuberculosis are also raised for a purpose. They are brought into the world for no other reason than what they can contribute to the fight against disease. They are well cared for and not allowed to suffer. It is true that some of them die untimely deaths just as the swine and cattle do, but in many instances they contribute far more to man's welfare than those animals whose carcasses are used for food.*

* Animals in a "state of nature" die "prematurely" in far greater proportions than is the case among domesticated or laboratory animals. It is obviously impossible for all the individuals who are born to survive to maturity. It is therefore a rather crude and unenlightened sentimentalism that focusses attention upon those premature deaths and even the sufferings of domesticated animals (including laboratory animals) and at the same time disregards the vastly greater suffering and death that would obtain both among beasts and among humans but for our "artificial" interventions—including animal experimentation. [Ed.]

BOOK REVIEWS

IMHOTEP TO HARVEY. BACKGROUNDS OF MEDICAL HISTORY. By C. N. B. Camac, M.D. N. Y., Paul B. Hoeber, Inc., 1931.

Whether you are ready for an advanced course in medical history, a beginner just feeling your way, or read medical history for the momentary pleasure it gives, you will enjoy and find Doctor Camac's book a gem.

Medical history, closely associated with that of education and science, is given in outline. Biography is not given, that being left to the reading suggested from time to time throughout the pages. The author draws attention to the fact he "has drawn the picture in large strokes."

The chapters comprise: The Evolution of Inquiry, Before the Greeks, Greek and Graeco-Roman Medicine, Middle Ages: Period of Retrogression for Science, Islamic or Arabian (Mohammedan) Medicine, Middle Ages (Continued): Universities and the Pre-Renaissance Period, The Renaissance, Environment of the Inquirer in the Medieval and Renaissance Periods, The 17th Century; The Beginnings of Modern Science, Schools of Thought in Medicine, The Greek Emblem in Medicine. Historic Records. The books ends with a List of Books on medical history and its many phases.

Doctor Henry Fairfield Osborn wrote the Foreword.

Our reaction after reading this book was: "delightful."

PERIPHERAL NERVE INJURIES

LEWIS J. POLLOCK, M.D.

AND

LOYAL DAVIS, M.D.

SECOND INSTALLMENT

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Chapter IV

EXAMINATION (*Continued*)

iv. Subjective Sensory Disturbances

Excluding causalgia, *pain* does not often result from injury of a nerve itself after the initial trauma. In our series, where pain has been present it has been boring, aching and rarely stabbing in character. Often it is found in cases in which the wound has been infected or when débridement with secondary suture has been performed, or when foreign bodies have been present. It commonly is worse at night and in the dependent position, and at times it is evoked by movement.

Paresthesias, pain and hyperesthesia were observed in what seemed to us to be a surprisingly small number of cases. From an analysis of 600 cases seen some months after injury, 161 cases were found to have sufficiently striking evidence of these to warrant a description in the history. Paresthesias were noted to have occurred in 62 patients. Mild paresthesias may be present at some time in many cases although the numbness complained of cannot be so classified because often it signified only a recognition of anesthesia. In patients seen immediately after injury the severe symptoms of coexisting diffuse injuries to other tissues often mask a mild paresthesia. At the time of injury the patient may experience pain described variously as pins and needles, an electric shock, a stab, lightning pain or as if the "crazy bone" were struck. This may be referred to the distribution of the nerve, but only too frequently the shock is so great that it masks such a symptom. Very frequently in the absence of shock or serious damage to other parts no particular referred sensation is observed, especially when a nerve is cut through, and this is usual in those wounds due to sharp instruments.

It is likely that the pressure of work in base hospitals, as well as the aforementioned concomitant injuries, explains the frequent absence from the records of some 500 patients seen

soon after injury, of a notation of the presence of subjective sensory disturbances. In all, less than 50 are so recorded. Of these, injuries to the sciatic nerve have the greatest number (20). Pain is seldom complained of with the exception of a few cases of causalgia. Hyperesthesia predominates and anesthesia is seldom mentioned. Many of these cases undoubtedly develop subjective sensations later since it was noted that causalgia, and, indeed, other sensations, appeared with the return of some function. When complete physiologic interruption still existed, subjective disturbances were rare. On the other hand, in such cases as were seen a few weeks after injury, especially the few patients who developed causalgia, very troublesome and constant pain was complained of. A characteristic note is as follows: "One month after injury formication and tingling over the ulnar distribution developed and gradually increased so that it was most severe two months after injury, since when the sensation has diminished considerably." Or: "At the seventh week formication appeared in the thumb and index finger; at the same time motion began to improve."

Some time after injury severe and persistent formication, pins-and-needles sensations, prickling, crawling and stinging sensations were relatively rare despite the accepted statement of their common occurrence. Naturally, such formication as occurs from manipulation, compression or striking an extremity and thus producing stimulation of the wildly growing axones in a neuroma must be excluded from such cases of spontaneous paresthesias. These spontaneous sensations occurred in 30 cases of sciatic nerve injury, in 13 of the peroneal, 4 of median, 8 of ulnar, 8 of radial, 4 of ulnar and median and 5 of brachial plexus injuries. In only 6 cases of complete section of the sciatic nerve was this observed. This latter observation holds true in a relative manner for the other nerves, not only for paresthesia but for pain as well. For example, only 2 of 15 cases of median nerve lesions giving a history of pain were thought to be complete lesions and in these the loss of pain sense represented a smaller area than is

commonly found. In ulnar nerve lesions the severe cases showed an equal number complaining of paresthesias but this was an exception. Although paresthesias occurred often in the presence of pain, usually only hyperesthesia was associated with the burning pain which will be described later. True tactile hyperesthesia rarely is encountered in peripheral nerve lesions. When stimulating a hairy part it may appear in an area of overlapping function.

An excessive reaction to painful stimuli evoking that peculiar sensation which has been ascribed to the protopathic fibers is constantly found in areas of overlap when sensation to pain has returned and anesthesia is present. It consists of a marked and quick withdrawal of the extremity which cannot be inhibited and is associated with a sensation of diffuse, unpleasant pain. This protective mechanism expressing a deficiency of sensation has been called a hyperalgesia but it is more properly classified as a reaction *sui generis*, as already pointed out by Head.

Hyperesthesias were more frequently observed than pain in the cases seen soon after injury. They were noted 17 times in the 42 cases of sciatic nerve lesions with subjective sensory disturbances; in 4 of 22 cases of peroneal injury; in 6 of 15 cases of median; in 3 of 23 cases of ulnar; in 3 of 13 cases of radial; in 4 of 16 cases of ulnar and median; and in 5 of 14 cases of brachial plexus injuries. In lesions of the nerves of the upper extremity they were observed in only 3 instances where the median nerve was not injured at some time in addition to the nerve remaining paretic. In the lower extremities only 2 cases occurred where the tibial may not have been injured as well as the peroneal.

Pain exclusive of causalgia does not often result as a consequence of a peripheral nerve lesion after the initial trauma. Concomitant lesions of the blood vessels, considered by some as a common source of pain, have not been found by us to be a constant factor in its production. In 16 severe lesions of the arteries, chiefly of the upper extremities, patients

complained of pain, varying from a dull ache to burning pain. However, the patients who suffered the greatest pain were those in whom the median nerve was injured.

Pain exclusive of causalgia was noted 25 times in the 42 cases of sciatic nerve lesions; 5 times in 22 peroneal injuries; 9 times in 15 median injuries; in 7 of 22 ulnar injuries; in 5 of 13 radial; in 7 of 16 ulnar and median; and in 7 of 14 brachial plexus lesions. It is again significant that in 3 of the cases of ulnar nerve lesions the median had been injured as well and function had recovered. In 2 of the radial nerve lesions the same circumstance had existed, and in all of the brachial plexus lesions the median was involved. Similar observations are true of the lower extremities with respect to the tibial nerve. In only 2 cases of median nerve lesions was there any possibility of a complete section of the nerve, and all of the brachial plexus lesions were recovering, or partial lesions. Only 5 of the 42 cases of sciatic lesions which produced pain were complete lesions. In general, as with paresthesia and hyperesthesia, pain was observed largely in incomplete or recovering lesions.

A study of the distribution of subjective sensory disturbances in sciatic nerve lesions and in combined lesions of the nerves of the upper extremity shows that when the median or tibial nerves were involved as well as some other nerve, the area supplied by them was more frequently the seat of such disturbance. In 23 lesions of the ulnar and median the area of the median nerve and the combined areas of both were the seat of subjective disturbances in 16 cases. The tibial nerve distribution alone was the area involved in 42 cases of sciatic nerve lesions.

The character of the pain varies from an ache to a boring, rarely stabbing, pain. It may be a soreness or a throb, occasionally a stinging pain. Usually it is increased after exertion. At times it is constant, with exacerbations brought on by movement and pressure, unusual position or stretching. The aching and boring is undoubtedly worse at night and with

the extremity in the dependent position. The outer surface of the foot, the plantar arch, the outer surface of the leg and calf are favorite locations. In the upper extremity, the palm, the thenar eminence, the index finger, the ulnar border of the hand, the dorsum of the forearm and, at times, the outer surface of the forearm are places of selection. Occasionally, pain is felt at the wrist joint in ulnar nerve lesions, at the elbow in radial injuries and at the head of the fibula in sciatic nerve lesions.

Chapter V

EXAMINATION (*Continued*)

v. Causalgia

In 1813, Alexander Denmark reported the case of a man wounded by a bullet which entered 1½ inches above the inner condyle of the humerus. The wound of exit was on the lateral side in front of the elbow joint. "He complained of a burning pain beginning at the extremities of the thumb and fingers, except the little one, and extending to the wound in the arm. The pain was of a burning nature and so violent as to cause continual perspiration from his face. He had an excoriation on the palm from which exuded an ichorous discharge."

Hamilton in 1838 described the glossy skin which is a part of the syndrome, and Paget completely described this condition in 1864. Wier Mitchell, Morehouse and Keen in the same year reported a series of cases under the name of causalgia. Mitchell's description is so comprehensive that it may be generously quoted, not alone for its historic interest but for its clinical value as well.

> The seat of burning pain is very various; but it never attacks the trunk, rarely the arm or thigh, and not often the forearm or leg. Its favorite site is the foot or hand. In these parts it is to be found most often where the nutritive skin changes are met with; that is to say, on the palm of the hand, or palmar part of the fingers, and on the dorsum of the foot; scarcely ever on the sole of the foot or the back of the hand. Where it first existed in the whole foot or hand, it always remained last in the parts above referred to, as its favorite seats.
>
> The great mass of sufferers described this pain as superficial, but others said it was also in the joints, and deep in the palm. If it lasted long it was referred to the skin alone.
>
> Its intensity varies from the most trivial burning to a state of torture, which can hardly be credited but which reacts on the whole economy, until the general health is seriously affected.
>
> The part itself is not alone subject to an intense burning sensation, but becomes exquisitely hyperesthetic, so that a touch or a tap of the finger

increases the pain. Exposure to the air is avoided by the patient with a care which seems absurd, and most of the bad cases keep the hand constantly wet, finding relief in the moisture rather than in the coolness of the application. Two of these sufferers carried a bottle of water and a sponge and never permitted the part to become dry for a moment.

As the pain increases, the general sympathy becomes more marked. The temper changes and grows irritable, the face becomes anxious and has a look of weariness and suffering. The sleep is restless and the constitutional condition reacting on the wounded limb, exasperates the hyperesthetic state, so that the rattling of a newspaper, a breath of air, another's step across the ward, the vibrations caused by a military band, or the shock of the feet in walking give rise to increase of pain. At last the patient grows hysterical, if we may use the only term which covers the facts. He walks carefully, carries the limb tenderly with the sound hand, is tremulous, nervous, and has all kinds of expedients for lessening his pain. In two cases, at least, the skin of the entire body became hyperesthetic when dry, and the men found some ease from pouring water into their boots. They said, when questioned, that it made walking hurt less, but how or why, unless by diminishing vibration, we cannot explain.

One of these men went so far as to wet the sound hand when obliged to touch the other, and insisted that the observer should also wet his hand before touching him, complaining that dry touch always exasperated his pain.

The relation of burning pain to altered nutrition in the skin was fully described by Mitchell:

The skin affected in these cases was deep red or mottled, or red and pale in patches. The epithelium appeared to have been partially lost, so that the cutis was exposed in places. The subcutaneous tissues were nearly always shrunken, and when the palm alone was attacked, the part so diseased seemed to be a little depressed and firmer, and less elastic than common. In the fingers there were often cracks in the altered skin, and the integuments presented the appearance of being tightly drawn over the subjacent tissues. The surface of all the affected part was glossy, and shining as though it had been skillfully varnished. Nothing more curious than these red and shining tissues can be conceived of. In most of them the part was devoid of wrinkles and perfectly free from hair.

Mr. Paget's comparison of chilblains is one which we often used to describe these appearances; but in some instances we have been more strikingly reminded of the characters of certain large, thin and highly polished scars.

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Nothing fundamental has been added to this description by the experience of the late war. Inasmuch as a large material is rare in civil practice, it is impossible to say whether the commonly accepted statement that causalgia is more often encountered in warfare is correct.

There is some confusion as to what constitutes a case of causalgia and many cases of burning pain have been recorded which do not correspond in all details to Wier Mitchell's description.

The almost constant association of glossy skin with burning pain led Wier Mitchell to believe that the burning itself depends for existence upon some nutritive alteration of the ultimate extremities of sensory nerves, although burning pain was encountered by him in numbers of men without glossy skin. Head has felt that the term "glossy skin" should be applied only to such cases as were described by Paget and Wier Mitchell, and is not to be confused with atrophic conditions not infrequently resulting from division of a peripheral nerve. Experience in the late war, however, has pointed out the existence of varying degrees of burning pain, and although some cases are associated with glossy skin many are not. Again, there occurred a considerable number of cases of glossy skin without burning pain. The predilection of these symptoms in the distribution of the median and sciatic nerves makes it probable that these nerves under certain conditions of pathology may produce glossy skin and burning, either alone or combined.

In our material of 1020 cases glossy skin not associated with causalgia was described in 41 cases; 15 of which accompanied median; 19, sciatic; 3, peroneal; 3, ulnar; and 1, radial nerve injuries. Pain in general was uncommon, whereas some form of paresthesia was found in about half of the cases. Contrary to Bénisty, who believes that glossy skin results from vascular lesions, these were very rarely noted in this group. On the other hand, of 38 cases of burning pain but 8 were accompanied by glossy skin. It may be noted in this connection, however, that in many of these recovery was taking place and the pain had diminished materially. In many instances severe burning

pain has been designated as causalgia, whereas moderate, or slight, burning pain, although possibly due to the same conditions, have not been so classified. As a result, statistics have only a relative value in this connection.

The pathogenesis as well as the pathology of this disorder is unknown. Many speculative theories have been proposed. Stopford has found partial division of the nerve and intraneural fibrosis, but identical changes have been observed in many nerves which did not produce the disorder. He believes that a secondary arterial thickening consequent upon injury to the vasomotor nerves is responsible for the symptoms. Leriche raised the question as to whether the condition is not due to a neuritis of the periarterial sympathetics. Meige and Bénisty believe that we are concerned with an inflammation of the fibers of the sympathetic system which follow the nerve trunks themselves and supply the glands, capillaries and nerve endings of the different layers of the skin.

Of the 161 cases showing subjective sensory disturbances, 38 cases of burning pain were found. Some doubtless would not ordinarily be classified as causalgia. On the other hand, it is significant that 33 of these cases occurred in patients who had either median or tibial nerve lesions alone or combined with some other nerve. Four cases occurred in ulnar nerve lesions and none in peroneal nerve lesions. Burning pain occurred in 8 of the 42 cases of sciatic nerve lesions; in 3 peroneal, 2 of which were residual from a former sciatic nerve lesion; 6 of the median nerve; 8 of the combined ulnar and median, 4 of which were residual from a median nerve lesion; in none of the radial nerve cases; in 3 of the brachial plexus lesions which involved the median, and in 2 posterial tibial nerve lesions. In only one case, that of the ulnar nerve, was there a complete lesion when burning pain was present. It is very likely that all patients who complain of burning pain, mild or severe, with or without glossy skin, are suffering with a certain grade of causalgia. The condition occurs most frequently in injuries of the median and sciatic nerves, occasion-

ally in the ulnar and usually when associated with the median, and very rarely in the radial nerve.

When the median nerve is affected the position of the hand

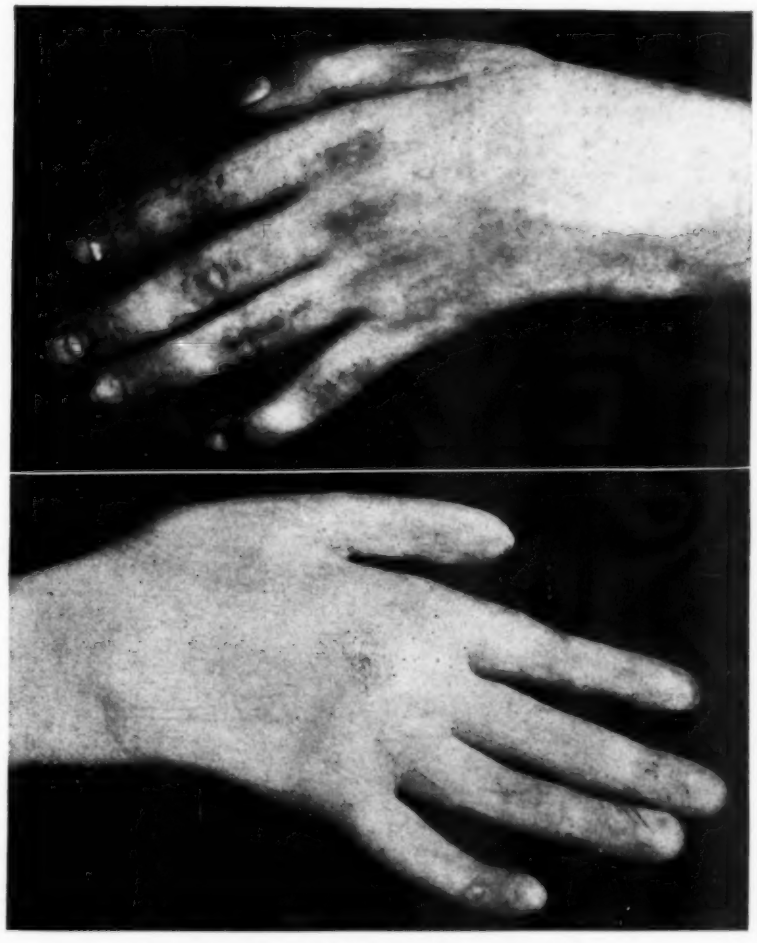

FIG. 27. Causalgia in a median nerve lesion.

is characteristic. It is held in a position wherein it is protected from jars, a dependent position, and stretching. The forearm is usually flexed, the fingers extended, at times hyperextended at the proximal phalanges, and the thumb is adducted. The hand appears slender, the fingers thin and tapering. The skin is fine, pink in the palm and often stretched and white on the dorsum. Blisters and papules often appear on the palm.

Constant wetting leads to maceration, with superficial ulcers. The nails are convex, pink, at times rapidly growing and curved inward. Longitudinal and transverse ridges in the nails are common. The finger tips become swollen and at times slightly clubbed. Commonly perspiration is diminished over the palm but increased over the dorsum, although in some cases perspiration is increased and appears in large beads over the radial side of the palm. (Fig. 27.)

The motor paralyses are slight, although some paresis is present in all cases, particularly in the small hand muscles. The painful character of the lesion prevents an accurate estimate of the actual motor deficiency because active movements are performed reluctantly. Slight irregular tremors and twitchings are common in the thumb and forefinger. Interphalangeal fibrosis and ankylosis are common and frequently an ankylosis occurs in the wrist joints in flexion.

The sensory disturbance is most prominent and commonly begins several weeks after injury, although some cases have been observed immediately after. It rarely affects the arm or thigh and not often the forearm or leg. Its favorite site is the foot or hand, the palm or palmar surface of the fingers, the root of the thumb and index finger. The third interosseous space, the inner side of the middle finger and the outer side of the ring fingers are often pointed out as the most painful spots. Although Wier Mitchell seldom found it over the sole, this has been the site of election in our cases. It often affects the tip of the toes and at times the dorsal surface of the proximal phalanges (Fig. 28).

The pain is described as piercing, throbbing, grinding, dragging, stabbing and burning. Paroxysmal exacerbations of a constant pain are characteristic. They are induced by physical and emotional causes. Exposure to air, dry heat, noise, bright lights, jarring from coughing, sneezing, laughing and the dependent position are common causes. As Wier Mitchell pointed out, emotional causes are common. Seemingly trivial experiences, such as meeting a relative, a physician's visit, the

witnessing of a quarrel or a surprise, may provoke a paroxysm. In aggravated cases the patient becomes shut-in, avoids society, cannot bear the laughter of fellow patients and remains

FIG. 28. Causalgia in a tibial nerve lesion.

in his bed in an attitude of defense. Relief from the burning pain is sought in the application of wet compresses, and the phobia to dryness spreads to other parts of the body. The phenomena noted by Wier Mitchell have been designated as synesthesalgia by Souques. In this condition touching the hand opposite the injured one, walking on dry feet, combing the hair, or even seeing another touch a dry object, provokes a paroxysm of pain. A curious case has been described by Fuchs, in which the burning pain was felt in the right hand in a left median nerve lesion.

Objective sensory disturbances vary. Hyperesthesia toward heat and cold is always present. Tactile sensibility is difficult to test either because of the hyperhidrosis or insistence upon keeping the extremity wet. Stimulation with an algesiometer produces a type of hyperalgesia which is similar to the protopathic response found in areas of overlap, and probably conceals a hypalgesia. It is often found that firm pressure produces less hyperalgesia than a light touch. Stereognostic sense is greatly impaired, and sense of position and vibration is disturbed.

The condition reaches its height four to five months after injury and tends to disappear slowly. Many cases so continue for a period of two years.

Chapter VI

EXAMINATION (*Continued*)

VI. Objective Sensory Disturbances

When a sensory or mixed nerve is physiologically or anatomically interrupted, loss of sensation occurs. Sensation may be lost wholly or in part. It may be lost for some or all types of sensibility.

Complete loss of sensation is properly termed *anesthesia*. Ordinarily this term is used to signify any degree of blunted sensation and is qualified by such adjectives as partial, complete or slight. It is limited further by such definitives as muscle anesthesia, tactile, thermic and joint anesthesia. The loss of the sense of pain is called *analgesia*, and this word may be qualified in a similar manner. By some authors the partial loss of temperature sense is called thermo-anesthesia and complete loss, thermo-analgesia. The former term may be applied more properly to the loss of appreciation of slighter changes in temperature; the latter to greater ones (epicritic and protopathic).

The examination of sensation, although simple, must be critical and painstaking. It should be made with the patient relaxed and comfortable. The extremity to be examined should be properly supported. The skin must be warm and, if hyperhidrosis is present, dried. Distracting noise or activity must be eliminated. Care should be taken to avoid fatigue and the patient should be permitted to rest a number of times during the examination.

The mental capacity and state of the patient must be kept in mind in evaluating the results. Apprehensive patients suffering with painful lesions are very apt to answer haphazardly and rapidly to shorten the ordeal. Attention frequently is difficult to hold and the patient's replies become stereotyped. It is necessary to guard against this by questions relating to the character of the sensation and its location. A

suggestion such as "Is this sharp?" should be avoided. It is better to ask, "What do you feel?" and "Where?"

The border of sensory loss may be determined by beginning the examination over the normal skin and approaching the anesthetic area. This is checked by beginning over the anesthetic area and entering the normal one. The borders obtained will not coincide exactly because in the latter instance attention is more readily held.

Diminution of sensation frequently results from changes in the soft parts exclusive of the nerves. For example, stretching of the skin as the result of hemorrhage, edema, or inflammatory changes, cyanosis and vascular lesions with consequent fibrosis of tissues, all produce sensory loss. Such loss is not limited to the sensory distribution of any one or more peripheral nerves. No areas of overlap can be made out. Frequently in the middle of an anesthetic area normal sensation is found. Peculiar dissociations, such as loss of pain and preservation of touch may be found. The skin over the body is not equally sensitive. This is true for all types of sensation. In general, it may be said that the arm and thigh are least and the tips of the fingers most sensitive. Thickening of the skin, calluses and failure of desquamation of the skin all diminish sensory activity, and due consideration must be paid to such conditions.

Touch or tactile sensibility may be tested for by a wisp of cotton. Simple methods of examination are best, and methods employed in physiologic research, such as v. Frey's hairs, need not be used. All hairy surfaces must be shaved several hours before examination. The degree of pressure must be varied somewhat in relation to the thickness of the skin tested, especially in the palms, soles and dorsal surfaces of interphalangeal joints. The pressure must be very light, insufficient to produce any indentation of the skin and thereby stimulation of deep sensation. Such methods as touching the skin with a blunt object, as a pencil, evoke deep sensibility and not touch sense. Two point discrimination sensation, although of physiologic interest, offers no valuable clinical date.

Although areas of analgesia may be found by examination with a pin or needle, more accurate methods are preferable to determine accurately the borders of loss of pain sense and to

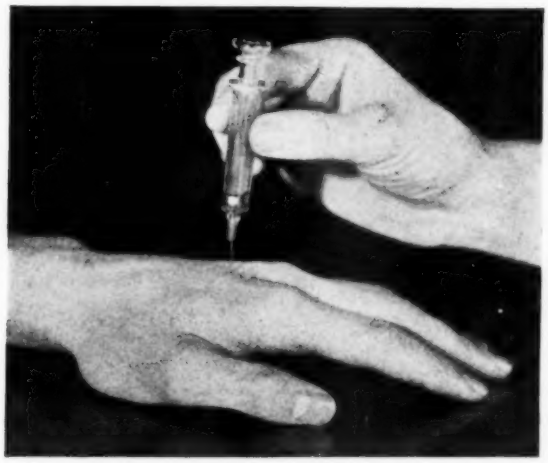

FIG. 29. Simple algesiometer.

follow the progress of sensory change from day to day. When areas of sensory loss are to be compared from time to time it is necessary to employ stimuli of known degree. Varying the degree of pressure produces different sized areas of sensory loss, and if low degrees of pressure are used the loss of touch and pain may be coextensive. If higher degrees of pressure, 5 to 10 grams, are employed the area of the loss to touch is far greater than the loss of pain.

A simple and accurate algesiometer may be constructed by placing a large headed pin in the barrel of a glass syringe, allowing the point to extend through the tip and replacing the plunger (Fig. 29). The weight of the plunger determines the degree of pressure when the pin is allowed to prick the skin, with the syringe held by the barrel. Various sized syringes may be used, varying degrees of pressure being thereby employed. It is important to distinguish between that sensation which is normal and that which arises in areas of nerve overlap to be described later. In the latter there is evoked a painful though

not necessarily sharp sensation, which is diffuse and difficult to localize. Sharpness and pain are not synonymous. (Fig. 30.)

Temperature sense must be tested for by relatively inaccu-

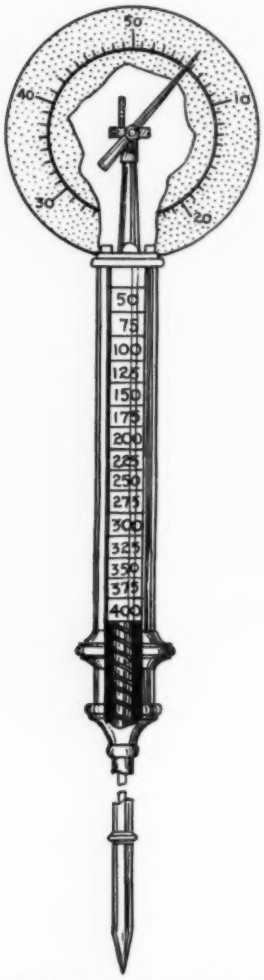

FIG. 30. Standard algesiometer.

FIG. 31. Cylinders for testing temperature sensation.

rate methods, such as test tubes which contain water of known temperature or, preferably, metallic cylinders which may be heated or chilled (Fig. 31). A rapid method of determining accurately the borders of loss of sensation to low degrees of temperature is the stimulation of the skin by a pledget of cotton twisted to a point and moistened with ether. As with

pain, so with temperature, stimulation and higher degrees of cold and heat stimulate the protopathic sensibility, and frequently in the areas of overlap the sensation evoked is

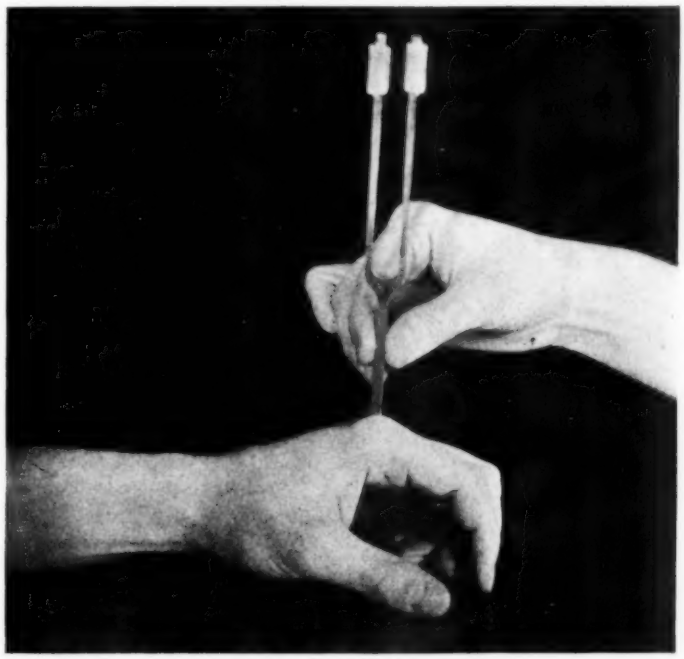

FIG. 32. Method of testing for bone vibratory sense.

unpleasant, painful and diffuse, in contrast to the actual temperature perception in a normal area.

Although Head's theory of the existence of separate nerve endings for protopathic, epicritic and deep sensibility is controversial, from a clinical standpoint it is useful to preserve some such classification. It is certain that with clinical methods these several sensations disappear and reappear in certain areas in a regular order.

Similar to Head's classification of cutaneous sensibility, J. S. Stopford divides deep sensibility into that "recovering" early (contact of pressure and pressure pain) and that recovering late or imperfectly (recognition of movement of a joint and localization of pressure). Contrary to former opinions, he

believes that the principal innervation of the deep tissues is by nerve fibers which arise from the main trunks and pass directly to the end organs. The supply by fibers which accom-

FIG. 33. Algiometer.

pany the motor branches and pass to their final distribution along tendons seems to be only supplementary.

The importance of the recognition of nerve overlap, which will be considered in detail later, is greater in the case of deep sensibility than of cutaneous sensibility. Unless the area of

isolated supply of a nerve for deep sensibility is known, and only that loss which is found within the limits of this area used as an indication of sensory loss, the conclusions will be mis-

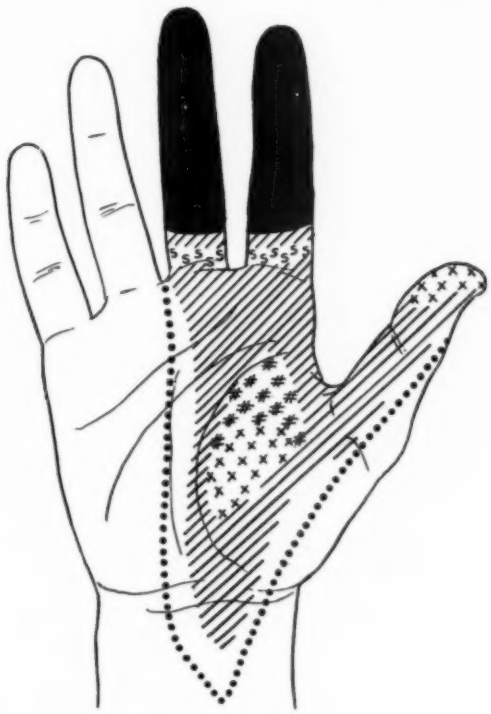

FIG. 34. Key for use in recording changes in sensation.

leading. As with cutaneous sensibility, so here, it is for that quality of sensation which returns early (pressure, contact and pain) that the greater overlap exists.

Deep sensibility including osseous sensibility may be tested by vibrations of a tuning fork (Fig. 32). This sensibility

is lost over that part of the bones usually innervated by the isolated sensory supply of the skin overlying them. Sense of contact of pressure should be tested by an algiometer (Fig. 33) with pressure insufficient to evoke pressure pain. The finger or a blunt instrument may be used. Sense of passive movement or tendon sense may be tested by passively moving the segments about a joint of an extremity which is supported and relaxed and having the patient repeat the movement on the opposite side and accurately describe it. Sense of position, or muscular sense, is tested by moving segments about more than one joint and after the movement has been completed and the extremity is at rest having the patient assume a similar position upon the opposite side. A simple key for charting changes in sensation is presented in Figure 34.

Chapter VII

EXAMINATION (*Continued*)

VII. Nerve Overlap

For many years it has been noted that total loss of sensation after complete division of a peripheral nerve is limited to a much smaller area than we would expect from its anatomic distribution. Likewise, it has been observed that following injury of a peripheral nerve sensory symptoms may rapidly diminish, and at times the loss of sensation to pin prick may be absent entirely. That severe widespread anesthesia results only from trauma of several nerve trunks of a plexus has generally been accepted. Lesions of single nerves result in partial anesthesia or, if a severe anesthesia is present, the area of complete loss of sensation rapidly shrinks.

Many attempts have been made to explain these phenomena. Among the older theories were: (1) that nerve fibers grow from healthy surroundings into the insensitive parts; (2) that after section of a nerve, stimulation of the severed part may pass through an accessory branch into an adjacent nerve and reach the major branch of the injured nerve above the lesion through a second lateral branch (collateral innervation—Létiévant); (3) that numerous anastomoses connect the peripheral ramifications of sensory nerves, so many cutaneous areas receive their innervation from different nerves. All these opinions have undergone important changes since the investigations of Head and his co-workers. The results of their brilliant studies led Head, Rivers and Sherren to conclude that:

> The sensory mechanism in the peripheral nerves consists of three systems:
>
> 1. Deep sensibility, capable of answering to pressure and to movement of parts and even capable of producing pain under the influence of excessive pressure, or when the joint is injured. The fibers, subserving this form of sensation, run mainly with the motor nerves, and are not destroyed by division of all the sensory nerves to the skin.

2. Protopathic sensibility, capable of responding to painful cutaneous stimuli and to extremes of heat and cold. This is the great reflex system, producing a rapid widely diffused response, unaccompanied by any definite appreciation of the locality of the spot stimulated.

3. Epicritic sensibility, by which we gain the power of cutaneous localization, of discrimination of two points and of the finer grades of temperature, called cool and warm."

Head and Sherren state that in complete division of a mixed nerve, as the median or ulnar, the area it supplies does not become uniformly insensitive. Whereas previous observers have stated that sensation is diminished over the full area usually assigned to the injured nerve and lost completely over a small portion only, they have shown that this diminution of sensation is in reality a total loss of sensibility to stimulation with cotton wool, to the compass test and to degrees of temperatures between 22° C. and 40° C. In this area are felt only the stimuli affecting the protopathic sensibility, such as the prick of a pin and temperature below 20° C. and above 40° C. The area rendered insensitive to light touch by division of the median or of the ulnar nerve varied little in extent. In sharp contrast to this slight variation stood the extreme difference in surface extent of the loss of sensation to pin prick which followed division of either of these nerves. "The consequence of both division and irritation of these nerves shows that as far as protopathic sensibility is concerned they overlap to an enormous extent."

From a study of 500 of our cases of peripheral nerve lesions observed soon after injury, it was seen that in many cases for the first two or three weeks only a very small area within the border of the part insensitive to cotton wool was sensitive to pin prick; that in a few a larger zone sensitive to pin prick appeared within fifteen days, and that the return of sensitiveness to pin prick in a larger zone, corresponding to the area which was later determined as nerve overlap, was found at times variable from thirty to 100 days.

It is essential to determine the cause of this relatively early return of prick pain. We must define that presence or return of

sensation which is due to partial lesions or the regeneration of a nerve and that which is due to the assumption of function of adjacent and overlapping nerves. It is to the misinterpretation of this early return of a prick pain that many early "recoveries" following nerve suture have been attributed.

The return of sensibility to prick pain that occurs before the return of sensibility to touch is due to the assumption of function by adjacent nerves. This return of prick pain always appears in similar areas in individual nerves and occupies the zone of nerve overlap. This zone may be determined by noting the residual sensation of a nerve.

The method of determining residual sensibility is based on the assumption that following section of a given nerve, the area of skin in the anatomic distribution of that nerve in which sensation remains is subserved by the intact adjoining nerves distributed to that area. For example, four nerves supply the palmar surface of the hand: the ulnar, median, musculocutaneous and radial. If two nerves, the ulnar and median, are severed that sensibility which remains is subserved by the musculocutaneous and radial. If, then, the borders of the musculocutaneous be determined, that which remains is radial (Figs. 35–38).

In employing this method certain precautions must be observed. For example, we cannot take the outer border of the analgesia on the dorsal surface of the hand in an ulnar section to be any part of the border of the overlap of the median unless we have observed the effect of a combined ulnar and radial nerve lesion so that the overlap of the latter nerve is not included. Similarly we cannot outline the border of the overlap of the median on to the radial unless we have a combined lesion of the ulnar and radial to indicate the distribution of the ulnar; or the overlap of the radial to the median on the palm unless we have observed the effects of a combined median and musculocutaneous lesion. Likewise we cannot outline the border of the overlap of the tibial into the area supplied by the peroneal unless we have had a combined lesion of the peroneal

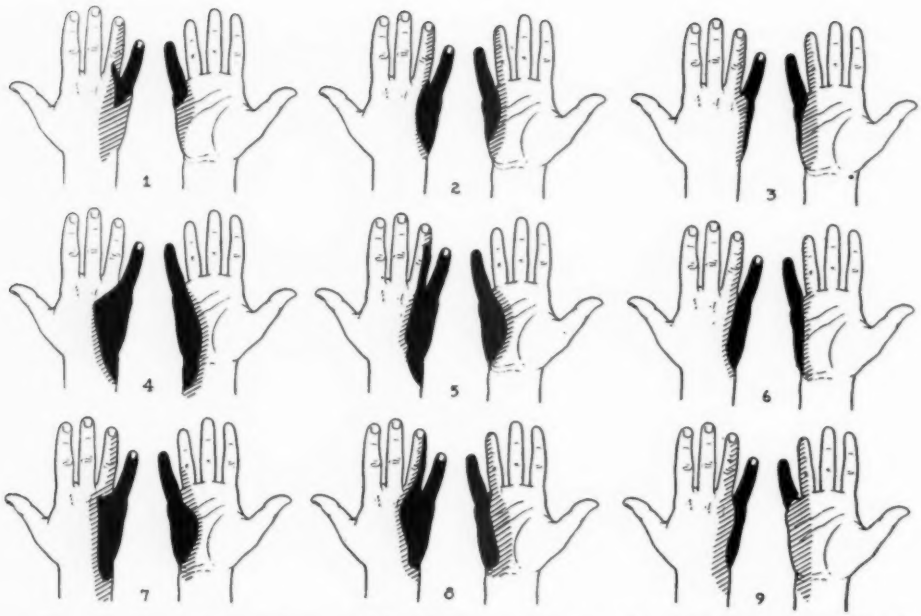

FIG. 35. Loss of sensation resulting from complete section of ulnar nerve. Algesic areas within accepted sensory supply of ulnar nerve are adjacent to intact median and radial nerves.

(1) Y. H. Gunshot wound, machine gun bullet. Upper third of forearm, July 18, 1918. Operated upon June 18, 1919. Examined July 21, 1919.

(2) J. K. Gunshot wound, high explosive. Above epicondyle, October 4, 1918. Operated upon March 12, 1919. Examination April 20, 1919.

(3) I. W. Gunshot wound, machine gun bullet. Upper third forearm, October 10, 1918. Operated upon September 13, 1919. Examined July 18, 1919.

(4) W. S. Gunshot wound, high explosive. Middle third forearm, September 27, 1918. Operated upon March 24, 1919. Examined April 20, 1919.

(5) T. H. Gunshot wound, high explosive. Middle third arm, October 28, 1918. Operated upon April 1, 1919. Examined April 23, 1919.

(6) J. M. Gunshot wound, high explosive. Middle third forearm, September 16, 1918. Operated upon September 17, 1919. Examined September 1, 1919.

(7) C. R. Gunshot wound, high explosive. Upper third forearm, October 11, 1918. Operated upon March 25, 1919. Examined June 1, 1919.

(8) C. N. Gunshot wound, high explosive. Upper third arm, October 17, 1918. Operated upon April 5, 1919. Examined May 10, 1919.

(9) W. P. Gunshot wound, high explosive. Middle third forearm, September 27, 1918. Operated upon September 6, 1919. Examined September 1, 1919.

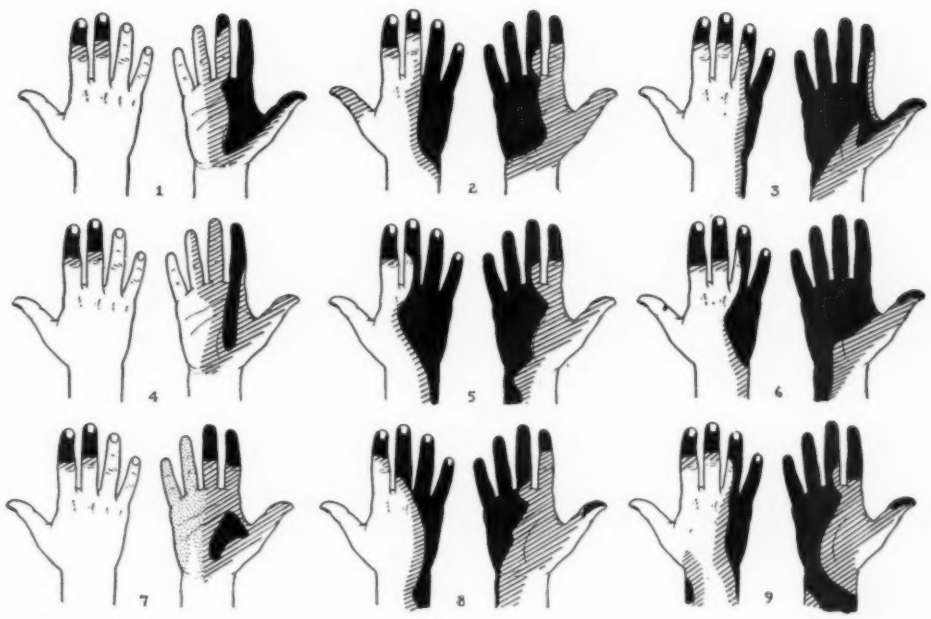

FIG. 36. Sensory loss following complete section of median nerve, 1, 4, and 7; median and ulnar nerves combined, 2 and 3; ulnar, median and medial cutaneous nerves combined, 5, 6 and 8; median, ulnar, musculocutaneous and medial cutaneous nerves combined, 9. Diagram 7 shows in addition to section of median nerve, slight hypesthesia over ulnar distribution due to a minor lesion of ulnar nerve. Diagram 9 represents the sensibility remaining in the hand after all the nerves with the exception of the radial, which supply sensation to the hand, have been severed. It follows that the radial nerve overlaps on to the palm to a large degree.

(1) V. A. Gunshot wound, high explosive. Lower third arm, Sept. 28, 1918. Operated upon May 21, 1919. Examined May 5, 1919.

(2) B. W. Gunshot wound, high explosive. Upper third forearm, Oct. 11, 1919. Operated upon April 18, 1919. Examined Apr. 18, 1919.

(3) G. P. Gunshot wound, machine gun bullet. Lower third arm, Oct. 31, 1928. Operated upon May 29, 1919. Examined May 17, 1919.

(4) R. A. Gunshot wound, high explosive. Right elbow, Aug. 4, 1918. Operated upon, May 5, 1919. Examined May 31, 1919.

(5) G. P. Gunshot wound, high explosive. Middle third arm, Oct. 4, 1918. Operated upon, April 5, 1919. Examined April 1, 1919.

(6) V. Q. Gunshot wound, high explosive. Middle third arm, Nov. 10, 1918. Operated upon, April 19, 1919. Examined, May 29, 1919.

(7) T. P. Gunshot wound, high explosive. Upper third forearm, Nov. 1, 1918. Operated upon May 27, 1919. Examined May 2, 1919.

(8) A. B. Gunshot wound, high explosive. Upper third arm, July 6, 1918. Operated upon May 6, 1919. Examined May 30, 1919.

(9) W. R. Gunshot wound, high explosive. Lower third arm, July 15, 1918. Operated upon June 29, 1919. Examined June 23, 1919.

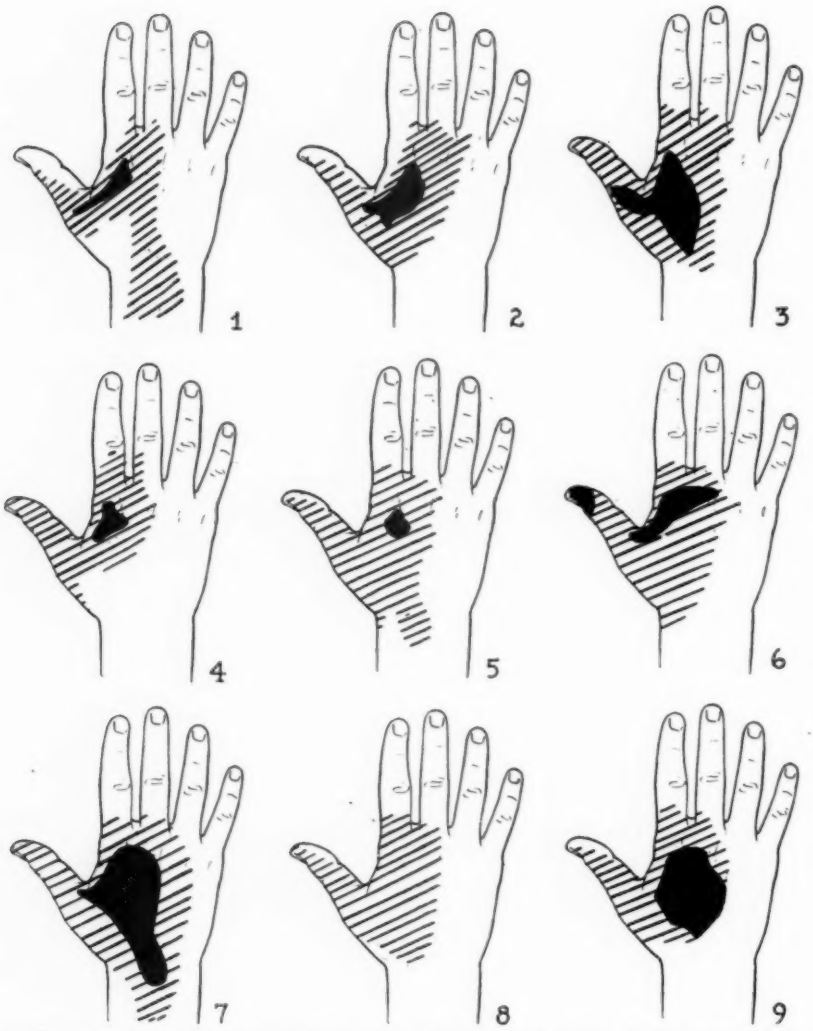

FIG. 37. Sensory loss which results from complete section of radial nerve. Diagram 8 illustrates that no analgesia may result.

(1) M. S. Gunshot wound, high explosive. Middle third arm, November 10, 1918 Operated upon May 21, 1919. Examined May 5, 1919.

(2) P. J. Gunshot wound, high explosive. Upper third arm, September 28, 1918. Operated upon May 16, 1919. Examined May 13, 1919.

(3) H. J. Gunshot wound, high explosive. Lower third arm, October 20, 1918. Operated upon June 3, 1919. Examined May 23, 1919.

(4) B. J. Gunshot wound, high explosive. Middle third arm, October 8, 1918. Operated upon March 22, 1919. Examined April 28, 1919.

(5) G. W. Gunshot wound, high explosive. Middle third arm, October 31, 1918. Operated upon March 17, 1919. Examined April 28, 1919.

(6) D. G. Gunshot wound, machine gun bullet. Upper third arm, October 26, 1918. Operated upon April 15, 1919. Examined May 18, 1919.

(7) W. L. Gunshot wound, high explosive. Upper third arm, October 31, 1918. Operated upon May 26, 1919. Examined May 1, 1919.

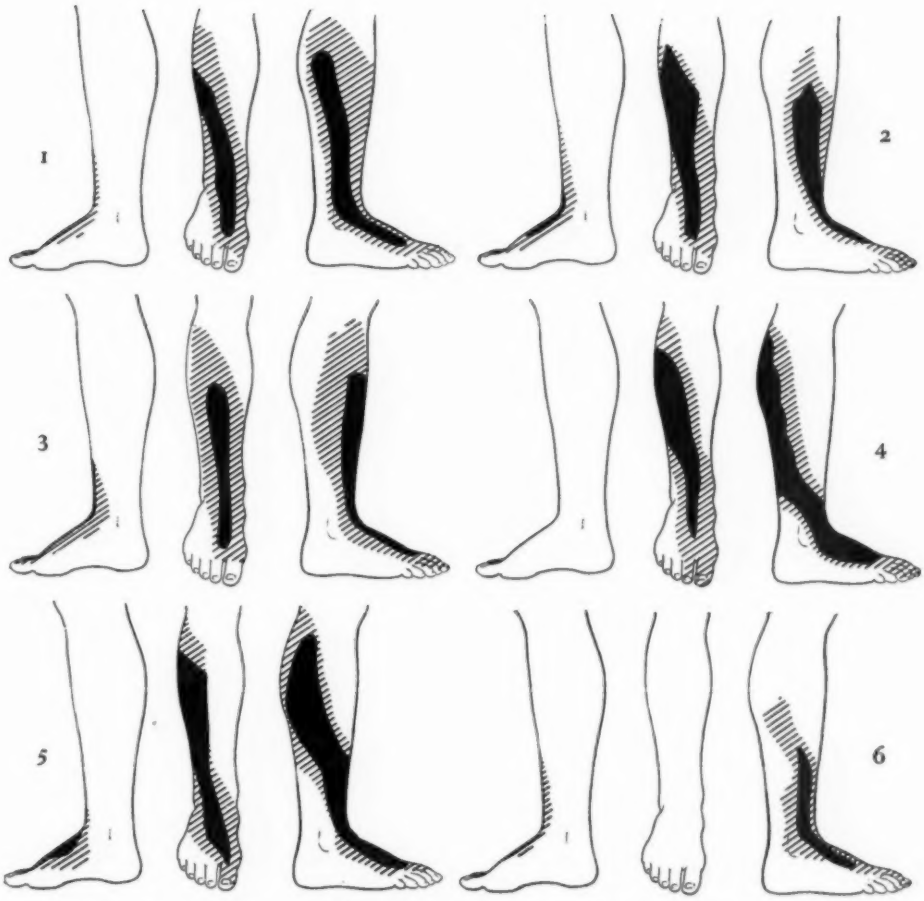

FIG. 38. Sensory loss resulting from complete section of peroneal nerve. Algesic areas within accepted sensory distribution of nerve are found adjacent to areas supplied by intact tibial and internal saphenous nerves.

(1) H. E. Gunshot wound, high explosive. Upper third leg, November 4, 1918 Operated upon May 8, 1919. Examined April 11, 1919.

(2) K. G. Gunshot wound, machine gun bullet. Upper third leg, October 14, 1918. Operated upon May 26, 1919. Examined June 30, 1919.

(3) S. F. Gunshot wound, machine gun bullet. Lower third thigh, August 17, 1918. Operated upon May 5, 1919. Examined April 28, 1919.

(4) K. J. Gunshot wound, high explosive. Knee, October 14, 1918. Operated upon May 5, 1919. Examined April 28, 1919.

(5) N. M. Gunshot wound, machine gun bullet. Upper third leg, June 24, 1918. Operated upon April 24, 1919. Examined June 15, 1919.

(6) S. W. Gunshot wound, machine gun bulletin Middle third thigh, October 3, 1918. Operated upon June 3, 1919. Examined July 29, 1919.

FIG. 37 (*Continued*):

(8) E. F. Gunshot wound, high explosive. Upper third arm, November 10, 1918. Operated upon May 8, 1919. Examined June 17, 1919.

(9) C. F. Gunshot wound, high explosive. Upper third arm, November 7, 1918. Operated upon April 22, 1919. Examined May 6, 1919.

with the internal saphenous. The necessity for these combinations reduces the number of cases available for conclusions to a very few. Owing to the lack of clinical material with certain

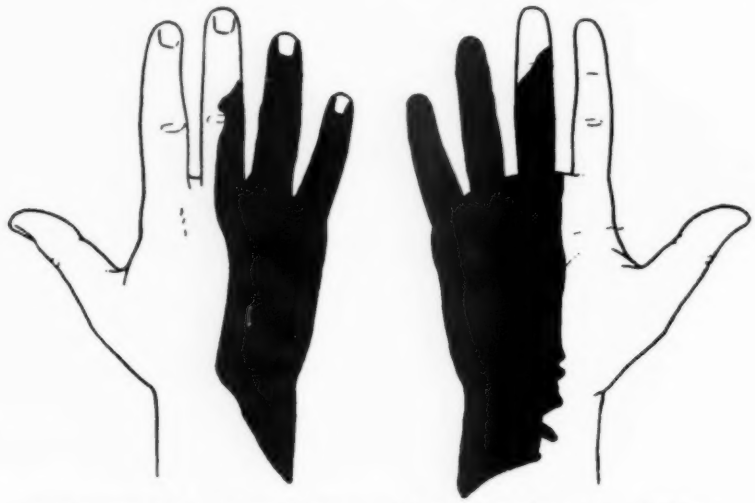

FIG. 39. Residual sensibility to pin prick in ulnar nerve lesion.

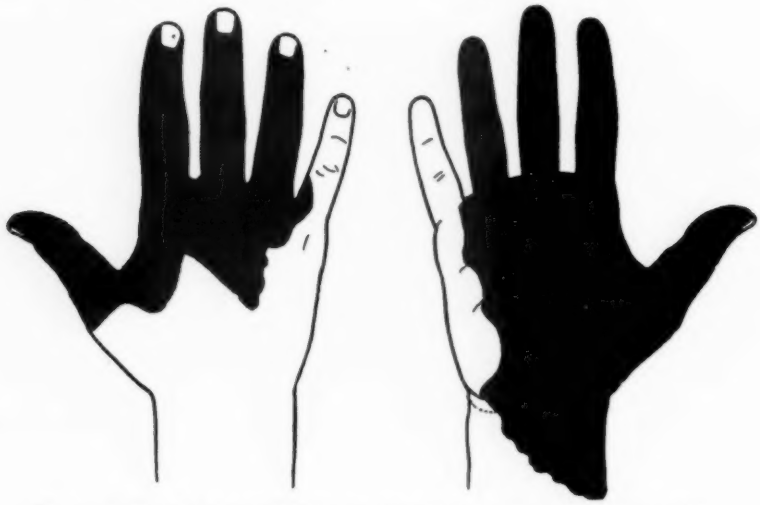

FIG. 40. Residual sensibility to pin prick in median nerve lesion.

combinations of nerve injuries, we have been unable to determine all the overlap areas of some of the nerves investigated. It is hardly necessary to state that the cases studied must have had the nerves recently resected or must have been examined

prior to an operation which revealed the ends of the nerve separated (Figs. 39–45).

In illustrating the areas of overlap, the space between the

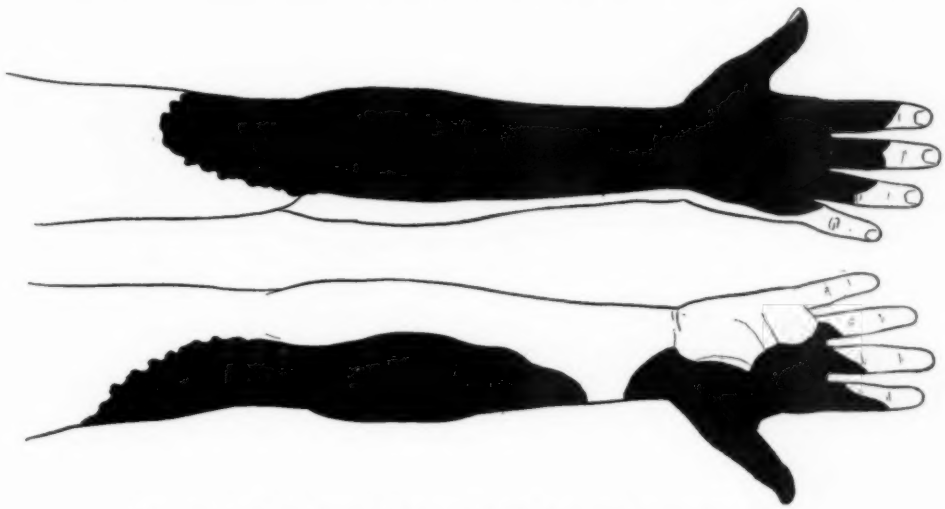

FIG. 41. Residual sensibility to pin prick in radial nerve lesions.

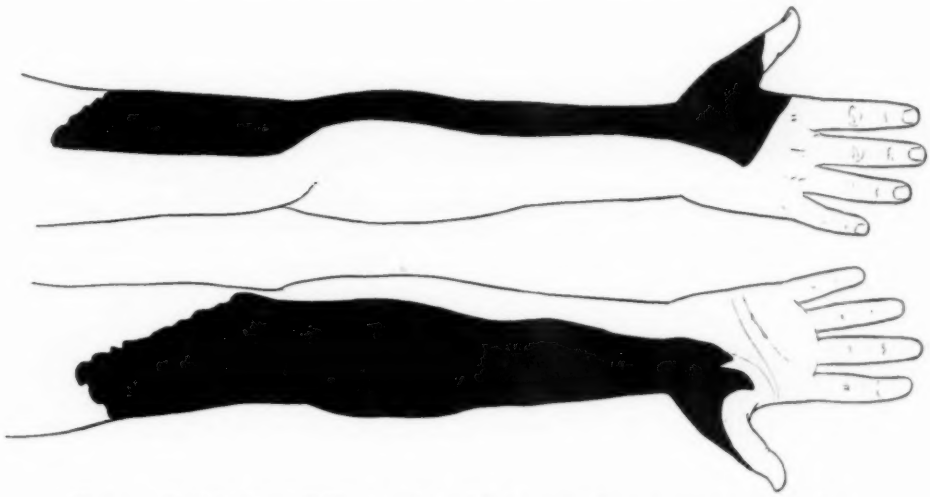

FIG. 42. Residual sensibility to pin prick in musculocutaneous nerve lesion.

borders of the overlapping to the adjacent nerves has been blocked out with black. The black area, therefore, added to the anatomic distribution of the nerve represents the total supply to pain of the various nerves studied. The areas of overlap to

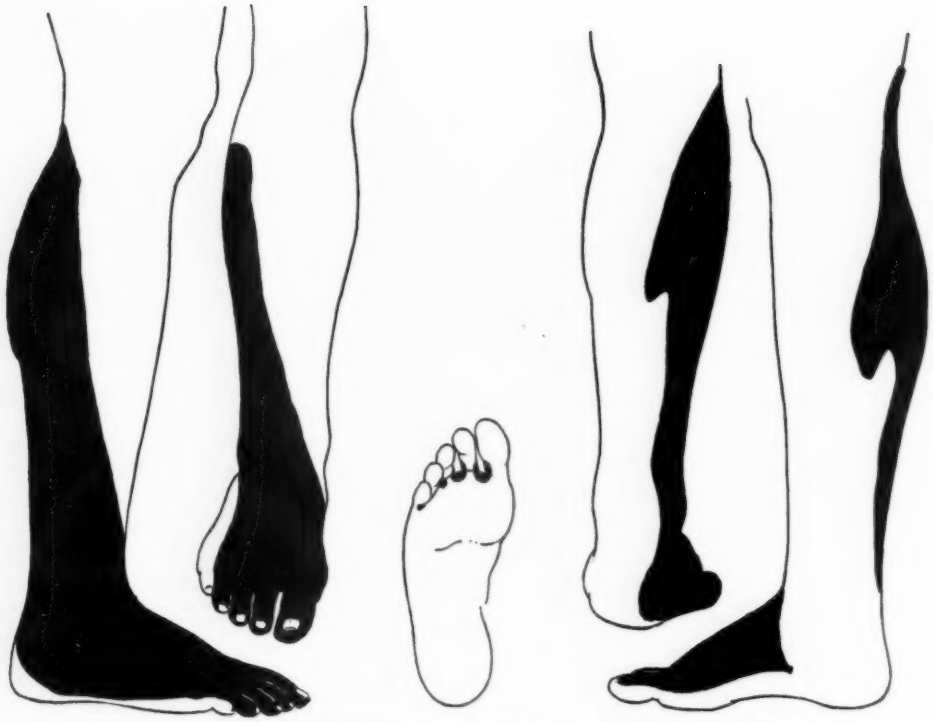

FIG. 43. Residual sensibility to pin prick in peroneal nerve lesion.

FIG. 44. Residual sensibility to pin prick in tibial nerve lesion.

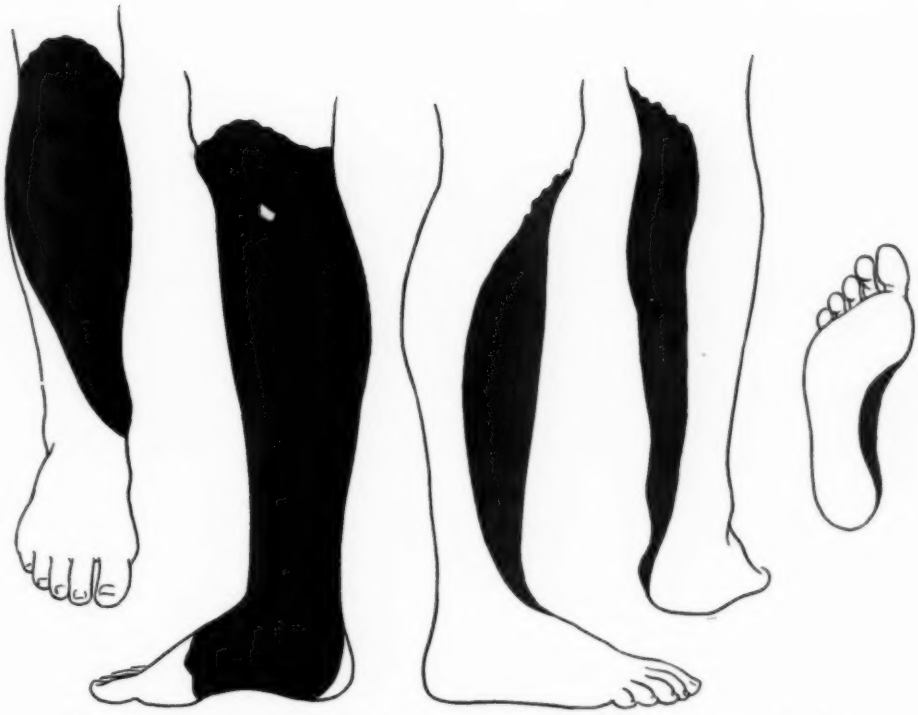

FIG. 45. Residual sensibility to pin prick in internal saphenous nerve lesion.

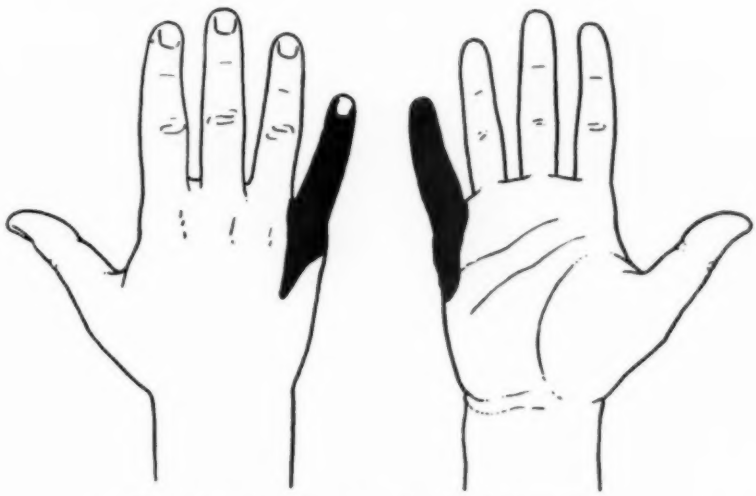

FIG. 46. Isolated sensory supply of ulnar nerve.

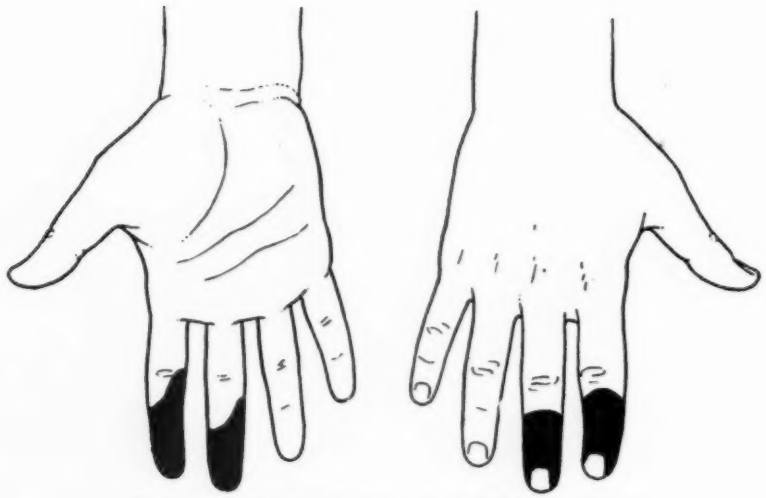

FIG. 47. Isolated sensory supply of median nerve.

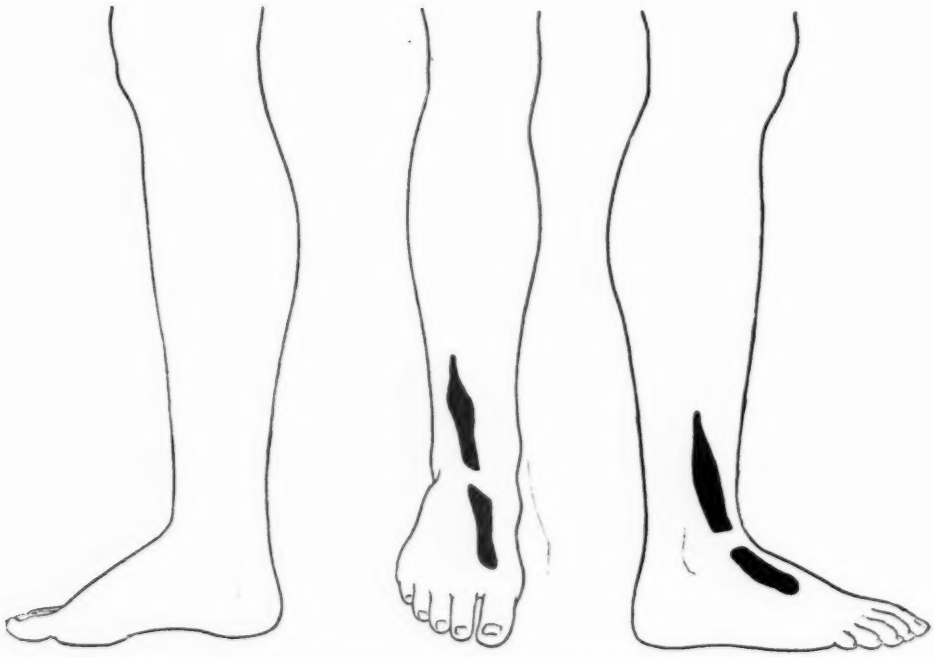

FIG. 48. Isolated sensory supply of peroneal nerve.

pain of the various nerves may be understood better by viewing the illustrations than by reading a description (Figs. 46–49).

If, therefore, the presence of return of sensation of pain in

FIG. 49. Isolated sensory supply of sciatic nerve.

the area of overlap cannot be interpreted as a sign of an incomplete lesion or recovery, it is necessary to outline the isolated supply to pain of each nerve. To delineate the area exclusively supplied with pain sense by a given nerve, one of two conditions must be present. First, the presence of pain sense having been demonstrated within the area of a nerve's supposed anatomical supply, that nerve must be found at operation to be divided and the ends separated. Second, the nerve having been seen to be divided, presence of pain sense is demonstrated in its distribution within the length of time given for the return of protopathic sensibility (Head, Rivers and Sherren, forty-three days).

The relatively few cases in our material does not make it profitable to attempt to outline the exclusive-supply of peripheral nerves to both epicritic and protopathic sensibilities. Suffice it to say that our results upon investigations of the epicritic sense in the hand are in general accord with Stopford. The areas of isolated supply to pain are shown in Figures

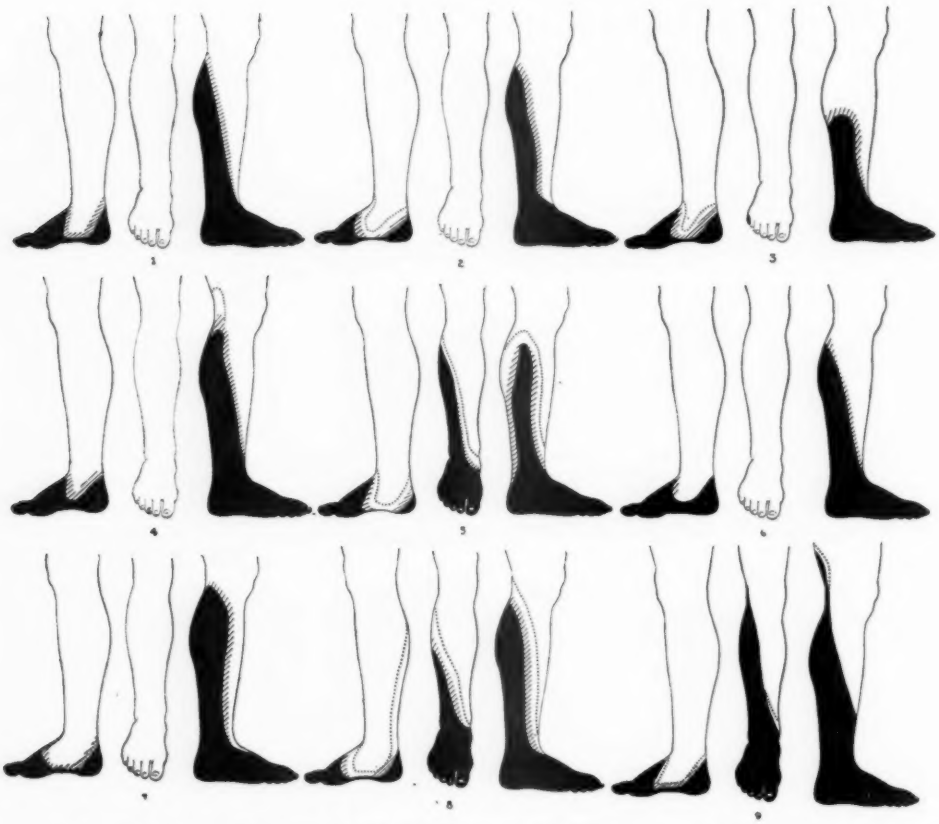

FIG. 50. Sensory changes which result from simultaneous section of more than one peripheral nerve in lower extremity (tibial and peroneal). No algesic zone can be found between areas supplied by these two nerves.

(1) L. J. Gunshot wound, high explosive. Middle third thigh, September 22, 1918. Operated upon March 19, 1919. Examined May 6, 1919.

(2) S. H. Gunshot wound, high explosive. Lower third thigh, October 4, 1918. Operated upon July 8, 1919. Examined May 5, 1919.

(3) W. P. Gunshot wound, machine gun bullet. Middle third thigh, July 31, 1918. Operated upon May 19, 1919. Examined May 3, 1919.

(4) D. C. Gunshot wound, machine gun bullet. Middle third thigh, October 1, 1918. Operated upon April 1, 1919. Examined May 20, 1919.

(5) H. C. Gunshot wound, high explosive. Lower third thigh, July 19, 1918. Operated upon January 27, 1919. Examined June 13, 1919.

(6) L. G. Gunshot wound, high explosive. Middle third thigh, October 10, 1918. Operated upon May 16, 1919. Examined July 10, 1919.

(7) L. H. Gunshot wound, high explosive. Middle third thigh, October 9, 1918. Operated upon April 7, 1919. Examined May 17, 1919.

(8) L. H. Gunshot wound, high explosive. Upper third thigh, October 9, 1918. Operated upon April 7, 1919. Examined July 7, 1919.

(9) H. S. Gunshot wound, high explosive. Right buttock, July 18, 1918. Operated upon July 8, 1919. Examined May 17, 1919.

46–49 and are described more fully under the description of the special nerves.

Inasmuch as the preceding illustrations represent the smallest area of exclusive supply of various nerves for pain, it is necessary to define to what extent they may be used in formulating our ideas relative to nerve overlap. In some instances such small areas may be present only when we are dealing with the group of 25 per cent of cases which show an unusual distribution of sensory nerves. These areas are used, therefore, only in establishing a certain limit beyond which it is not permitted to go in interpreting return of sensation to pain as a sign of nerve regeneration.

It is necessary to allude briefly to the proof that the early presence or return of sensation to pain upon the borders of the anatomic distribution of a nerve is due to nerve overlap and not to regeneration or partial loss of function. If the shrinkage of the area insensitive to pin prick, responsible for the increase in size of the intermediate zone, be a sign of nerve regeneration and not a result of overlap, it should occur whether or not the adjacent nerves are intact. This is not the case, however. Isolated lesions of the peroneal nerve may show only a small area of analgesia, but when the tibial as well as the peroneal is severed there is never any shrinkage of analgesia or reappearance of sensibility to prick pain in the zone where the supply of the peroneal meets that of the tibial (Fig. 50). Although in isolated lesions of the ulnar nerve sensibility to pain is frequently seen on the ulnar half of the ring finger, this is never observed when a median nerve is divided at the same time (Fig. 51). When the ulnar, radial and median nerves are divided, a year may follow their division and no shrinkage of analgesia be found on the palmar or dorsal surface of the hand, except on the proximal portion of the analgesia where the musculocutaneous and the antibrachii posterior areas adjoin the analgesic area (Fig. 52). When a radial lesion is combined with a median, analgesia is always present on the radial part of the palm. When a median lesion or a radial lesion alone is present,

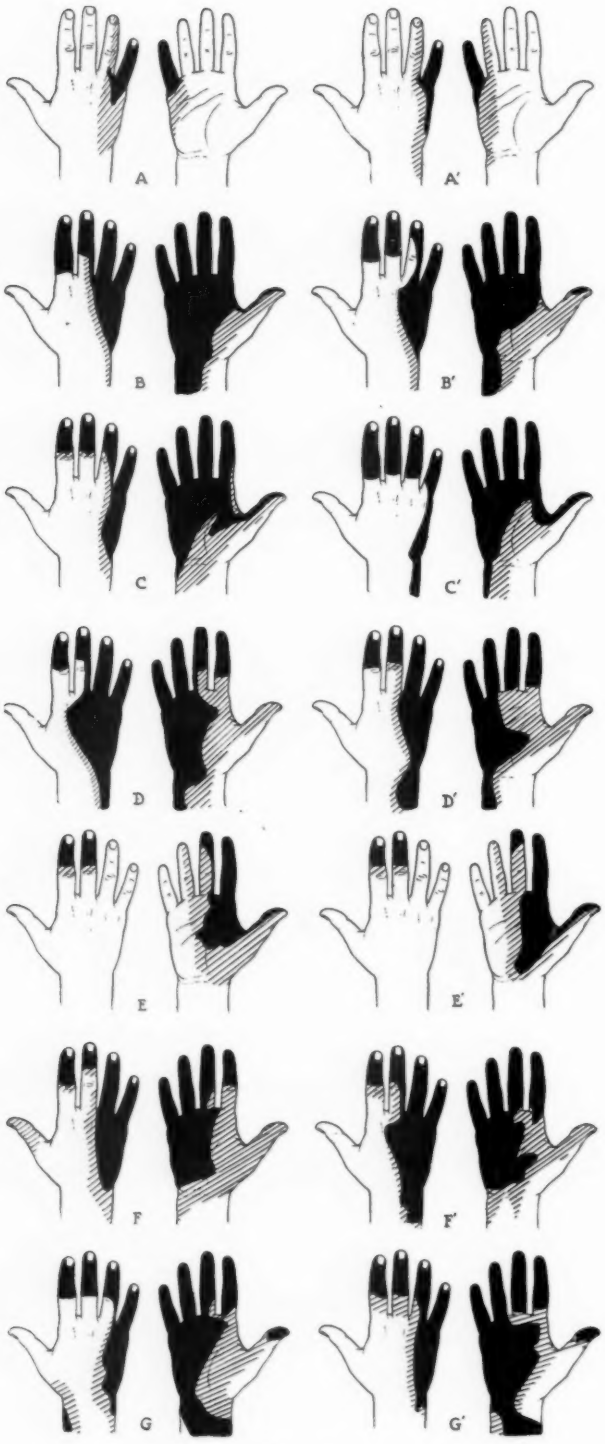

FIG. 51.

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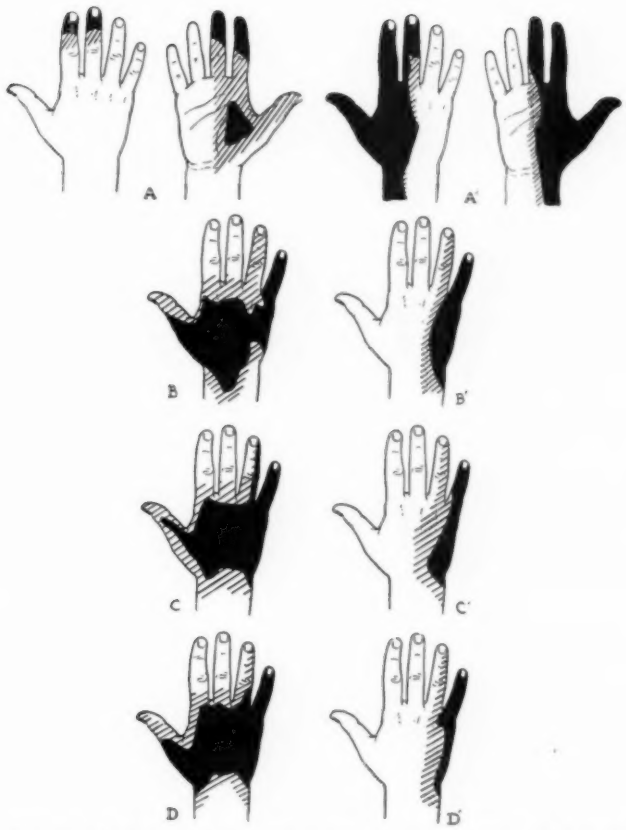

FIG. 52. A, Sensory loss resulting from a complete section of the median nerve; A', when the superficial radial nerve was subsequently severed, the preexisting sensibility of the radial side of the palm disappeared. B, C, D, Sensory loss on dorsum of hand resulting from complete section of ulnar nerve. B', C', D', when the superficial radial nerve was severed subsequently to be used as a transplant, the algesic area found within the sensory distribution of the ulnar nerve disappeared.

FIG. 51. Sensory changes before and after resection and suture of various peripheral nerves. A, before, A', after resection and suture of ulnar nerve; B, C, D, before, B', C', D', after resection and suture of ulnar and median nerves in cases with additional lesions of median cutaneous; E, before, E', after resection and suture of ulnar and median nerves; G, before, G', after resection and suture of ulnar, median and musculocutaneous nerves.

A, Examined July 21, 1919; operated upon June 8, 1919. A', July 21, 1919.
B, Examined April 5, 1919; operated upon April 4, 1919. B', May 29, 1919.
C, Examined May 17, 1919; operated upon May 29, 1919. C', July 8, 1919.
D, Examined April 1, 1919; operated upon April 5, 1919. D', May 29, 1919.
E, Examined May 5, 1919; operated upon May 21, 1919. E', June 1, 1919.
F, Examined April 18, 1919; operated upon April 18, 1919. F', May 30, 1919.
G, Examined June 23, 1919; operated upon June 29, 1919. G', July 11, 1919.

this part of the palm is usually sensitive to pin prick. It can be definitely stated also that when nerves supplying adjoining areas are severed, sensation to pain is at no time present in the

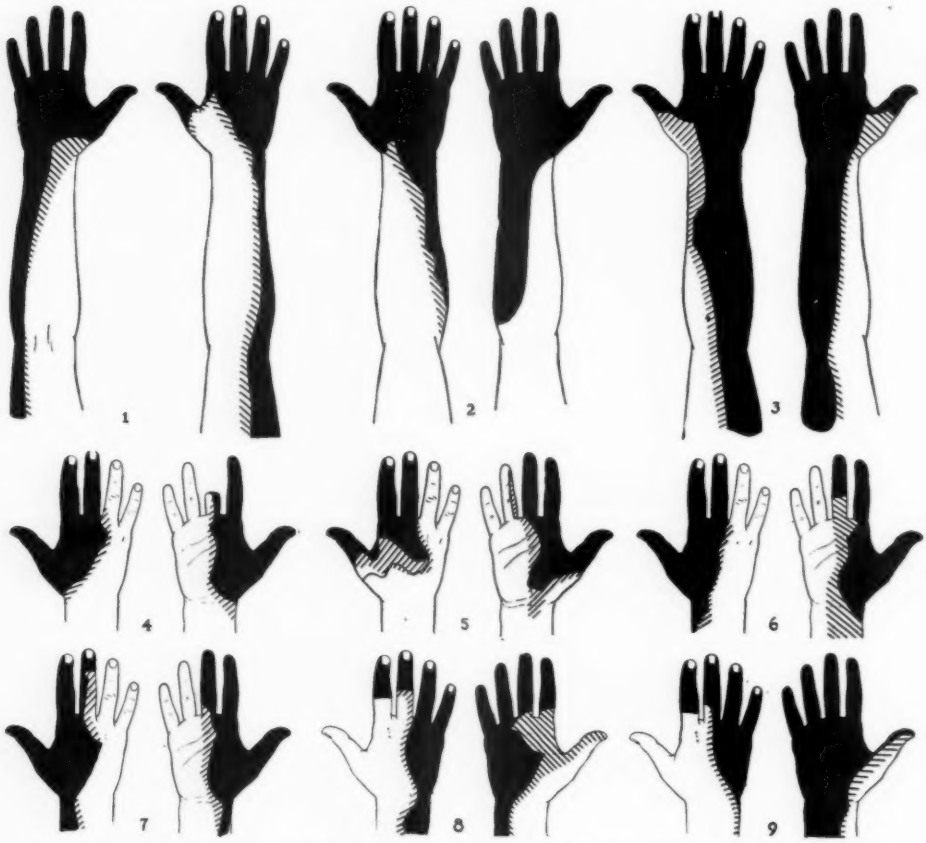

FIG. 53. Sensory loss resulting from simultaneous section of more than one nerve.

(1) Ulnar, median, radial, medial cutaneous of arm and forearm.
(2) Ulnar, median, radial and medial cutaneous of forearm.
(3) Ulnar, median, radial, medial cutaneous of arm and forearm.
(4, 5, 6, and 7) Radial and median.
(8, 9) Ulnar and median.

In no instance is there return of pain sensibility upon borders between sensory distribution of several severed nerves.

border areas, where it is uniformly observed when either nerve is divided alone (Fig. 53).

Inasmuch as a large number of our cases have had resections and sutures performed at least three months prior to the

last examination, it may be stated likewise that no sensation to pain returned in such areas in the time given for the beginning of regeneration of protopathic sensibility. If certain areas of skin become sensitive to pain or are found sensitive to pain following the section of a given nerve and if this condition is due to nerve regeneration, then section of the adjacent nerve should have no effect upon the appearance of this sensibility. However, it was constantly found that when return to sensibility to pain or presence of sensibility to pain was found in the area of overlap of an adjacent nerve, analgesia resulted if this nerve was severed. In a case in which a partial ulnar lesion was combined with a complete section of the median nerve prick pain was preserved in the radial portion of the palm and index finger. When the superficial radial nerve was resected at operation for use as a cable transplant, this part of the palm became analgesic. This proves that the sensation present in the radial portion of the palm and index finger was subserved by the radial nerve. Likewise in cases of complete section of the ulnar nerve in which the superficial radial nerve was severed and used as a cable transplant, the pre-existing sensibility to pain on the radial border of the sensory supply of the ulnar nerve disappeared, proving that this sensibility was subserved by the radial nerve.

Resection and suture of nerves does not produce an analgesia in an area of overlap into which the sensation of pain has returned. The conditions necessary to study profitably the effect of resection and suture of nerves on return of sensibility to pain are: first, that the nerve ends be separated and, second, that the examination subsequent to operation be made within the period of time ascribed to the return of protopathic sense as the result of regeneration. The areas which are sensitive to pin prick in the lesions examined and the sensory changes following operation need only be illustrated. It is sufficient to state that the following nerves were studied; ulnar, examined 42 days after operation; ulnar and median, 45, 36, 40, 46 and 14

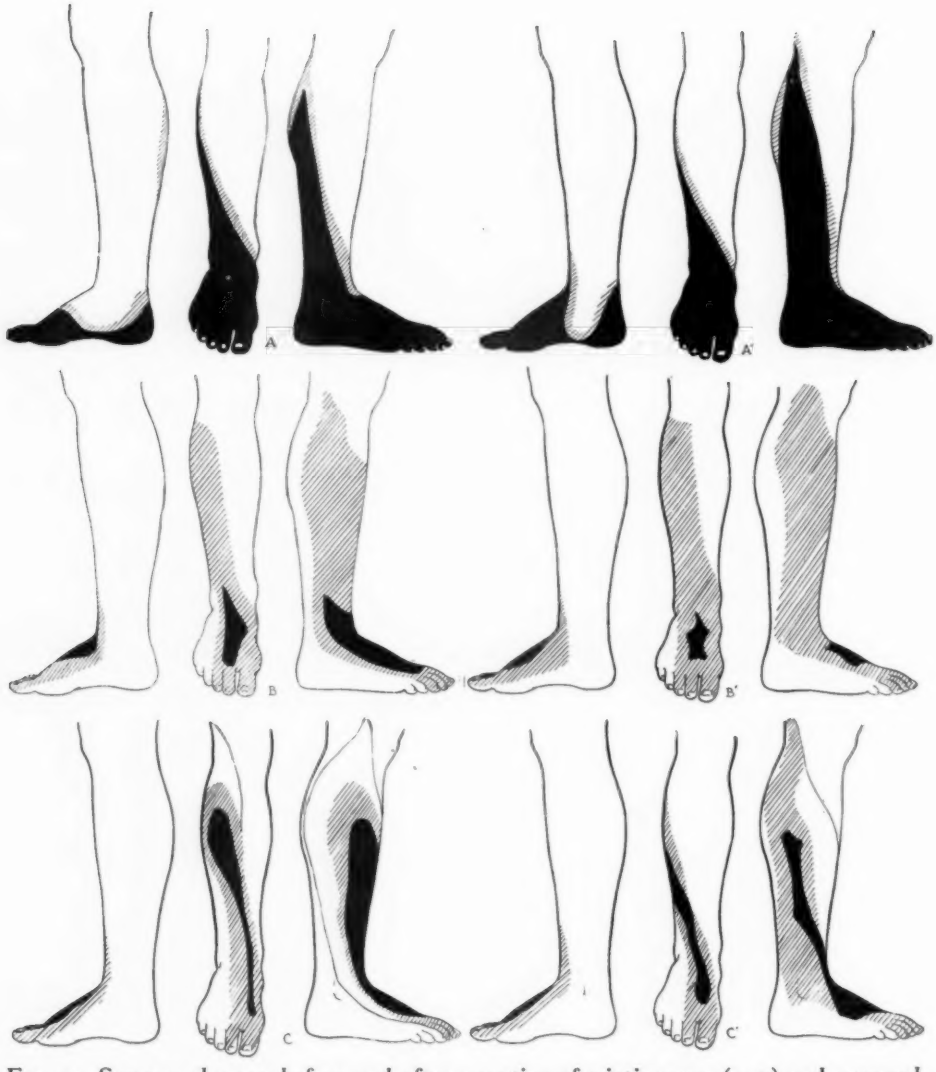

FIG. 54. Sensory changes before and after resection of sciatic nerve (A, E) and peroneal nerve (B, C, D, F).

A, Examined June 16, 1919; operated upon July 21, 1919. A', July 29, 1919.
B, Examined May 30, 1919; operated upon July 7, 1919. B', July 29, 1919.
C, Examined May 15, 1919; operated upon June 4, 1919. C', July 22, 1919.

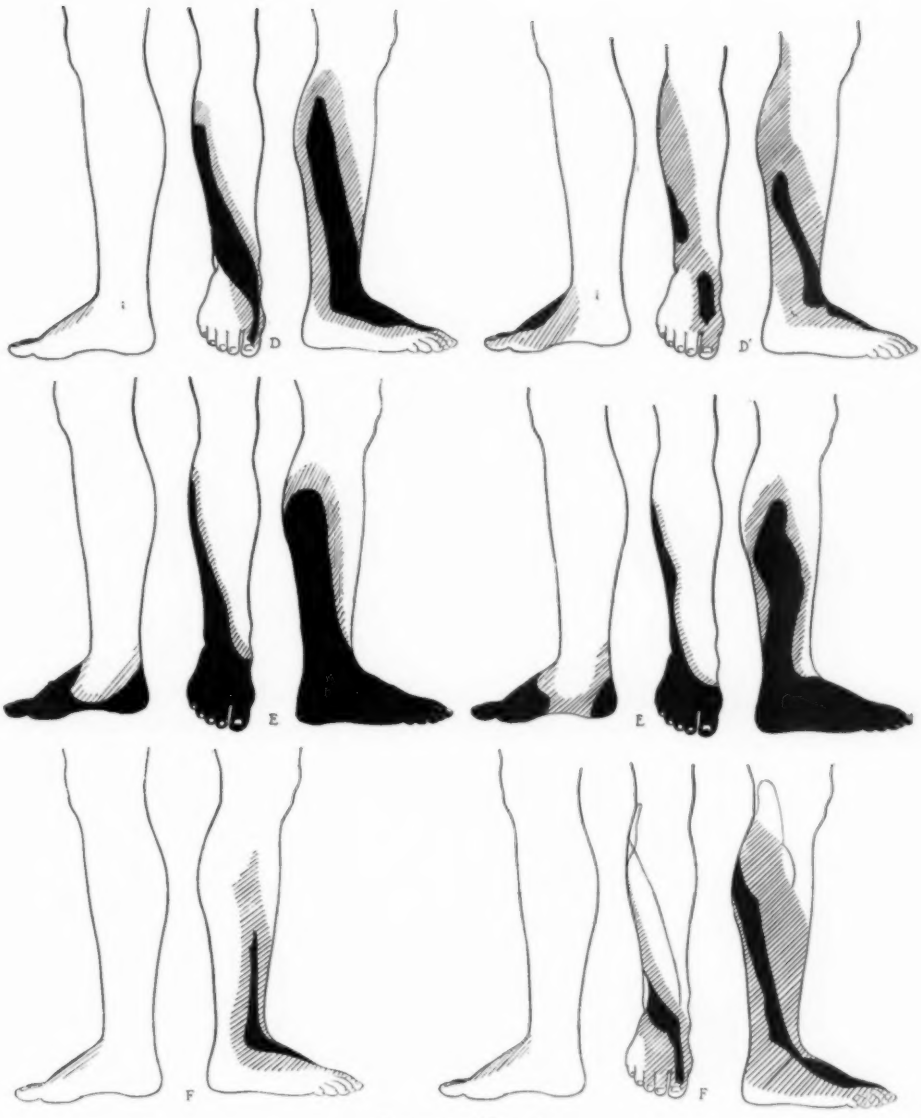

FIG. 54. (*Cont.*)

D, Examined May 30, 1919; operated upon July 9, 1919. D′, August 9, 1919.
E, Examined June 29, 1919; operated upon June 23, 1919. E′, August 29, 1919.
F, Examined June 5, 1919; operated upon May 1, 1919. F′, May 31, 1919.

days after operation; peroneal, 48, 36, 20 and 26 days after operation; and sciatic, 50 and 36 days after operation (Fig. 54).

Head and Sherren state that: "Sometimes it is necessary to divide an injured nerve, after sensibility to prick has already begun to return to the hand, that more perfect union may be obtained. Wherever such an operation has been performed, the parts that had begun to recover sensibility became again insensitive to prick, a proof that the recovery must have been due to union, however imperfect, of the divided nerves." In cases which show a return of sensibility to pain as the result of actual regeneration, subsequent resection would be expected to produce analgesia. Similarly, the existence of sensibility to pin prick in a partially severed nerve would be destroyed if that nerve were resected. The whole area of the anatomic sensory supply of a nerve must be rendered analgesic following resection before it can be stated that no part of the return of sensation was due to overlap. In all of our cases, dissociated return of pain sense occurred within the area of nerve overlap and remained intact following resection and suture. Nowhere have we found an illustration of dissociated return of pain sense except in such an area of overlap.

The preceding observations show that the dissociated return of sensibility of cutaneous pain occurs only in areas of possible overlap. When several nerves serving adjacent areas are severed simultaneously, sensibility to cutaneous pain is not present after injury, nor does it return before tactile sensibility in the borders between these areas where it is commonly present when one nerve is severed alone. When a region in the area of sensory distribution of a severed nerve is sensitive to cutaneous pain, and this region is adjacent to another nerve area, if this latter nerve be severed complete analgesia results in the previously sensitive region.

When sensibility to prick pain is present or returns in the area of possible overlap on to the sensory distribution of the severed nerve, subsequent resection and suture of this nerve does not change the general extent of this sensitive area,

although the borders may at times be slightly enlarged or diminished. That is, the pain sense which returned or was present before the operation was not due to partial regeneration.

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